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SHOCKS FROM HIGH-TENSION CABLES.

In the issue of the ELECTRICAL REVIEW for April 23, reference was made to a fatal accident in one of the London (England) generating stations, and to the explanation offered by the London *Electrician*, which was based upon an assumed residual charge on the cable. In view of the statement of the condition of the station at the time of the accident, this seemed to be the only possible explanation. Since then the *Electrician* has received a number of letters from prominent engineers, all of them disagreeing with this explanation. The greater number take the stand that, on account of the confusion caused by the accident, it is probable that the conditions at the station were not exactly as explained by the attendants. It is possible that one of the synchronous motors might have been left connected to the mains, and that this machine was the cause of the attendant's death. It seems that sometimes the synchronous motors are not disconnected when the generating station is shut down, but the switches are left closed, so that the motor will start up again with the generator. Several of the communications refer to severe shocks from static charges on high-tension cables, but in no case had the cables been discharged, so that the shock was not due to a residual charge. Doubtless, the investigations which will be made of this accident will bring to light the real cause; and whatever this may have been, whether a static charge or carelessness at one of the substations, it emphasizes the danger of assuming that a high-tension cable is safe to handle at any time. It is not a sufficient precaution to see that the switches at the generating station are off, but means should be taken to render all those cables which must be handled harmless, even though a high potential should be applied at the other end of the line.

THE REGULATION OF ALTERNATORS.

The paper presented by Messrs. H. M. Hobart and F. Punga at a recent meeting of the American Institute of Electrical Engineers, on the regulation of alternators, offers a new method of attacking a problem which has at various times received a good deal of attention. There have been put forward, from time to time, various solutions, a number of which give, under ordinary circumstances, quite satisfactory results, though all depend more or less upon compromises. The new method is based upon a study of the magnetic distortion produced by the armature reaction. The distortion may not only affect the value of the electromotive force, but may actually change its phase with reference to the pole. This change in phase of the electromotive force, caused by the shifting of the centre of gravity of the magnetic flux, has not been considered in the methods previously described, and an investigation of this action is, in itself, valuable, aside from the interest which the paper has as a new contribution to a subject not yet thoroughly understood.

Study of Regulation Important.

That there are a number of methods of predetermining alternator regulation which are sufficiently accurate for practical purposes, shows that, while we do not understand the matter fully, we have had sufficient experience to enable us to design machines which will meet any prescribed requirements satisfactorily. But this should not hinder further attempts to place this problem on a more scientific basis. It may not be very important for a designer to be able to predict exactly how his machine will behave, because one can never know beforehand the precise conditions under which it will work eventually, and therefore any calculations made must be based upon assumptions, which are apt not to hold good. This is perhaps what was meant by some of those who took part in the discussion, when

they said that the topic was one of interest, but of little importance. Scientifically, however, it is not unimportant. The very fact that we do not understand fully all the reactions of the alternator shows that there is something still to be learned, and anything that throws new light upon the behavior of a dynamo must be of value. In designing the magnetic and electric parts of a dynamo, it is not allowable to determine the limiting amount of material and then adopt a large factor of safety of two, three or five and go ahead. The designer is expected to know exactly the amount of iron and copper required, and how to use this to obtain the best results; and if he uses too much material, the machine not only costs more, but it may not be suitable for the purpose for which it was designed. It is therefore essential that he should understand, as thoroughly as possible, the fundamental reactions of his machine, for only in this way can he hope to improve. For this reason, any study of the behavior of dynamos, if based on accurate data, is helpful, in so far as it gives us a better understanding of what is happening in the machine, and why it happens.

THE ALUMINUM ELECTROLYTIC CONDENSER.

On another page of this issue will be found a full abstract of a paper upon "The Aluminum Electrolytic Condenser," which was presented by Mr. C. I. Zimmerman at the recent meeting of the American Electrochemical Society. This is a very interesting device, whose action depends upon the peculiar behavior of aluminum when used as an electrode in certain solutions. The apparatus does not belong to the same class as the ordinary electrolytic condenser formed of an electrolyte and soluble electrodes. In this latter device the condenser effect is due to polarization electromotive forces, the behavior being practically that of a storage battery having a small capacity. The aluminum electrolytic condenser, on the other hand, is a static condenser, though of a peculiar kind, as is clearly brought out in this interesting paper.

The Action of Aluminum.

The behavior of the aluminum plates in the condenser is practically the same as in the electrolytic rectifier. We say "practically," because there is a slight difference, in that, in the rectifier, there is a passage of current from the electrolyte to the aluminum electrode once during every cycle, while, in the condenser, this action takes place only when the condenser is first connected into the circuit. The characteristic behavior of aluminum in certain electrolytes is the formation of a thin insulating film during the passage of current from the plate into the electrolyte. The flow of current will be stopped as soon as the film is completely formed. This film, however, does not prevent the passage of current from the electrolyte to the electrode. In the rectifier this film is broken down at points once during every cycle, allowing current to flow; but the breaks are repaired almost instantaneously upon reversal of current. In the aluminum condenser there is at no time a complete conducting path through the device, because, no matter in which direction current tends to flow, there is always one film which opposes it.

A Bound Charge.

One of the peculiar features of this condenser is the bound charge which it contains. If such a condenser is connected to a source of direct electromotive force one or the other of the aluminum plates—depending upon the direction of the electromotive force—is positively charged and the electrolyte negatively charged. Disconnect the condenser from the source of electromotive force and make metallic connection between the two aluminum plates, and the condenser will attempt to discharge, the positive charge of the aluminum plate flowing around through the connecting wire to the other plate, and the negative charge flowing across through the electrolyte. But two charges can not mix and neutralize, because of the film on the other aluminum plate. To discharge the condenser completely, it is necessary to use an auxiliary electrode of some other material, which will allow the bound negative charge to flow out of the electrolyte and neutralize the positive charge on the two plates. When the condenser is connected in an alternating-current circuit it behaves in the same way. During the first half cycle the electrolyte becomes negatively charged, and this negative charge then oscillates in the electrolyte from one pole to the other, the quantity of this charge depending upon the maximum value of the applied electromotive force.

An Analogous Arrangement of Static Condensers.

Mr. Zimmerman, in a note also published in this issue, proposes an hydraulic analogy which illustrates very nicely the action of the aluminum electrolytic condenser. It can also be compared with a system consisting of two static condensers connected in series, one of the condensers having been charged before the connection was made. Under this condition there is always a bound charge which can not be got rid of by connecting the external terminals of the system together, a metallic connection with the internal connections being necessary. This system will behave as the aluminum electrolytic condenser, provided the maximum value of the electromotive force is never greater than the electromotive force which caused the first charge. Such an increase would call for an increase in the bound charge, which could not take place unless a momentary metallic connection were made around one of the condensers. In this system of two static condensers connected in series, the bound charge will for an instant be concentrated entirely on one condenser; the other condenser, having no charge, will show no difference of potential between its plates. This condition is just reversed when the electromotive force reverses. The capacity of the system for an alternating current is half of that of either condenser alone, and the energy discharged which would be obtained upon connecting the external terminals together would be half the total energy of the system.

Practical Value of Alternating-Current Condensers.

The aluminum condenser, besides being an exceedingly interesting device, has a number of useful properties. It is practically indestructible, since the dielectric is self-healing. It has a large capacity, and is highly efficient if not used for too high a voltage. It is also inexpensive, and if used frequently enough to keep the films formed, it would seem to have a considerable practical utility.

THE TELEPHONE SITUATION IN ENGLAND.

The telephone situation in England is somewhat peculiar. At this time there are two systems—that of the post office and that of the National Telephone Company. At the end of the current year the post office will have the power to purchase the National Telephone Company, and from recent parliamentary proceedings, it appears that it is looking forward to carrying out this plan, as the postmaster-general has asked the House of Commons for an appropriation of $15,000,000. The post office is now furnishing telephones in London at a little under $40 a year, although it is only required not to ask more than £10 ($50). This rate was for an unlimited service, while the service provided is for £5 ($25) a year, plus a charge of one penny to twopence per call, according to the section called. The average capital cost per subscriber for the post-office telephone system is $500, and it seems unlikely it will be any less for some time to come. According to the statement of Lord Stanley, the postmaster-general, the total investment in post-office telephones—trunk, provincial and London—is $20,870,000, and the total revenue is $2,250,000, something less than eleven per cent. This income can hardly be remunerative for a business which requires the employment of much skilled labor and uses apparatus having a high rate of depreciation. Yet the post office seems to desire extending its system by the purchase of the National Telephone Company, which would then be operated at a loss.

Opposition to the Plan.

The British technical papers are practically a unit in criticising the plan of the post office, and take the stand that it is not only unjust to the taxpayers, but that it will greatly hinder telephone development in England. The telephone service which the post-office department can furnish now is far less than that which is demanded, and the development, compared with American cities, is small. It is not thought possible for the post office to meet the public demands, since the capital available for this purpose is necessarily limited and can only be secured by slow processes. Moreover, from the stand taken by the postmaster-general, who seems to wish to convey the impression that the present rate is profitable, it will be impracticable for the post office to charge for service at a rate which will be remunerative.

BRITISH ELECTRIC RAILWAY SUCCESS.

The Mersey Railway Company, which electrified the railroad connecting Liverpool and Birkenhead last year, has reported to the shareholders upon the operation since electric trains were put into service. This road, which runs through a tunnel under the Mersey river, had been operated by steam up to the time of the change in system. It had not been profitable, and traffic had fallen off greatly, due to the discomforts of the trip. After electrification, the speed of the trains was increased and the schedule much improved. The six months of operation show a good increase in traffic, though this is not quite as large as the increase in train-miles. However, the traffic seems to be catching up to this gradually.

Cost of Propelling Trains Reduced.

The cost of propelling trains has been much reduced by the change. Under steam, the cost of the energy for one train-mile was 22.6 cents. With electricity, it is 10.4 cents. It is said, also, that the cost of maintaining the permanent way has been reduced by more than one-half. The total working expenses with steam traction for the six months ending December, 1902, were eighty-two cents per train-mile. During the corresponding period of last year, with electric traction, they were thirty-six cents per train-mile. One unsatisfactory item has been the maintenance of cars, notwithstanding that the car equipment was new. The reason for this is not clear, but it may be due to the including in this item of the cost for repairs of the electrical equipment of the cars, while the similar item for steam locomotive repairs was not included under this head previously.

THE ELECTRICAL MANUFACTURE OF STEEL.[1]

BY GUSTAVE GIN.

EXAMPLE OF APPLICATION OF PROCESS BY OXIDATION.

For an iron containing:

Carbon	3.60 per cent.
Silicon	1.68 "
Manganese	1.10 "
Phosphorus	0.62 "

The proportions of the above impurities have been chosen arbitrarily to facilitate calculation. The composition of a ton of pig iron may, in fact, be represented by the simple formula here given, expressed in kilogramme-molecules:

$$16.6Fe + 3C + 0.6Si + 0.2Mn + 0.2P$$

If we suppose that the finished steel contains 0.96 per cent carbon, and 0.28 per cent silicon; and if we admit for the simplification of the formulæ that the other impurities are practically eliminated, the total reaction may be reduced to the equation:

$$\frac{x(16.6\ Fe + 3C + 0.6Si + 0.2Mn + 0.2P..)}{\text{Pig iron.}} + \frac{y Fe_2O_3}{\text{Ore.}} + \frac{z CaO}{\text{Lime.}}$$
$$= \frac{17.7Fe + 0.8C + 0.1Si}{\text{One ton of steel.}} + \frac{(3x - 0.8)CO}{\text{Carbon monoxide disengaged.}}$$
$$+ \frac{x(0.5SiO_2 + 0.2MnO + 0.6CaO + 0.6FeO) + 0.1x(P_2O_5 4CaO)}{\text{Slag.}}$$

From this it follows that the production of a ton of steel requires:

Pig iron	919 kilogrammes.
Fe_2O_3	218 "
CaO	56 "

The quantities eliminated theoretically amount to 57.6 kilogrammes, while there is a recovery of 134.8 kilogrammes of iron. We may admit, as practical, the following figures for the production of one ton of steel by the method of oxidation:

Consumption of pig iron	924 kg.
Iron ores (75 per cent Fe_2O_3)	320 "
Lime	56 "

ENERGY CONSUMED.

The calorific energy derived from the electric current is utilized as follows:

a. Heating the metallic bath from 1,300 degrees to 1,750 degrees centigrade.

b. Heating the reagents to 1,600 degrees centigrade.

c. Chemical reactions.

d. Radiation losses.

a—Heating the metallic bath:

We raise the temperature of 924 kilogrammes of iron from 1,300 degrees to 1,750 degrees. But between these two temperatures the specific heat of the iron varies between 0.40 and 0.58 (which gives

[1] Reprinted from the *Electrochemist and Electrometallurgist*, London, March, 1904.

0.48 as mean value). The heat consumed is therefore:

$q_a = 924 \times 0.48 \times 450 = 199{,}600$ calories.

b—Heating the reagents:

The specific heats (average) of Fe_2O_3 and CaO between 0 degrees and 1,600 degrees centigrade are respectively 0.19 and 0.23, so that the heat consumed in heating the reagents is:

$q_b = (320 \times 0.19 \times 60 \times 0.23 \times 1600 =$ 119.400 calories.

c—Chemical reactions:

By balancing the heats of formation of the compounds which occur in the two members of the above equation, we have:

$q_c = 75{,}000$ calories.

The total of the calories expended for the heating of the masses, and the chemical reactions is therefore:

199,609 + 119,400 + 75,000 = 394,000 calories,

which corresponds to a consumption of 456,000 watt-hours per ton of steel manufactured.

d—Radiation losses:

The masonry of the furnace structure being heated by preceding operations, the iron destined for the next operation is introduced at a temperature which does not materially exceed that of the interior of the furnace. The calorific emission of the bath is, therefore, of but minor importance at the beginning, but it increases as an exponential function of the heating of the metal, which is at first very rapid, when nearly all the heat generated by the current is used in heating.

To reduce these losses, when the temperature of the bath reaches 1,500 degrees centigrade, it is covered with some of the ore and lime.

At the very first these reagents are heated as much by radiation from the furnace interior as by contact with the bath, of which the radiation is momentarily almost annulled. When the reagents have been converted into slag and fused, radiation occurs at the surface of the liquid slag; later, when the purifying reactions have terminated, the slag is cleaned off, and the surface of the bath being exposed radiation becomes intense, the temperature finally tending to reach a point where there is a balance between the generated and dissipated heat.

From a few experiments which were made, it has been concluded that the emission of heat from a carefully installed furnace may be expressed provisionally by the following formula, derived from that of Stephan:

$$w = a\,S T^4\,\theta \qquad (1)$$

where

w = the dissipated energy expressed in watt-hours,

$a = 8{,}125 \times 10^{-16}$,

S = radiating surface of the bath of steel $= l\,c$ (l and c being the length and upper surface of the metallic stream),

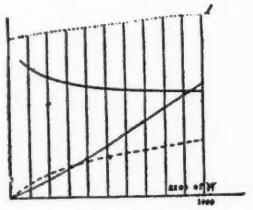


FIG. 5.—CURVE *l* (SCALE $\frac{1}{100}$), CURVE *c* (SCALE $\frac{1}{10}$), THE THIN, DRAWN-OUT CURVE GIVES THE WEIGHT OF METAL PER OPERATION; THE THICKER CURVE THE EXPENDITURE OF ENERGY PER TON.

T = temperature (maximum absolute) = 2,000 degrees centigrade.

θ = time in hours.

From the above it follows that

$$w = 5\,l\,c\,\theta \qquad (2)$$

TOTAL EXPENDITURE OF ENERGY.

For a furnace of power W, producing P kilogrammes of steel per operation, during θ hours, the calorific expenditure would be equal to

$$W\theta = 466P + 5lc\theta \qquad (3)$$

DATA OF CONSTRUCTION AND YIELD OF FURNACES.

The preceding formulæ may be represented under another form. Admitting that the density of the liquid iron equals 7, we have

$$7lc^2 = 1000P \qquad (4)$$

or

$$lc^2 = \frac{1000P}{7} \qquad (5)$$

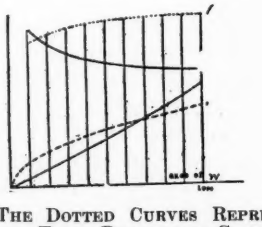


FIG. 6.—THE DOTTED CURVES REPRESENT *l* AND *c*, THE THIN, DRAWN-OUT CURVES THE WEIGHT OF METAL PER OPERATION; THE THICK CURVE THE EXPENDITURE OF ENERGY PER TON.

It may also be noted that any given moment we have

$$W = \frac{E^2}{R} = \frac{E^2c^2}{Pl} \qquad (6)$$

In order not to introduce new variables, suppose that the moment of commencing a furnace run is the precise instant chosen for the verification of the preceding equation. At this moment we know approximately the value of $P = 216 \times 10^{-6}$ and we will assume that E = 15 volts. We therefore evolve from (6) the following equation:

$$\frac{l}{c^2} = \frac{104 \times 10^4}{W} \qquad (7)$$

From the equations (6) and (7) we deduce

$$l = 122000\sqrt{\frac{P}{W}} \qquad (8)$$

$$C = 0.108\sqrt[4]{PW} \qquad (9)$$

$$lc = 1318\sqrt{\frac{P^3}{W}} \qquad (10)$$

This latter value, substituted in equation (3), gives

$$W\theta = P\,(456 + 6590\theta\sqrt[4]{\frac{1}{PW}} \qquad (11)$$

Admitting that a single operation will occupy three hours, the time necessary for the reactions, we may show, by means of equation (11), the following curves for the values of *l*, *c* and P, as a function of W:

APPLICATION OF THE MIXED PROCESS.

Again taking up the figures of the preceding application (oxidation process), we may write the equation which symbolizes the ensemble of the reactions, thus:

$$\frac{x(16.6Fe + 3C + 0.6Si + 0.2P + \ldots) + \underset{\text{Pig iron}}{}}{\underset{\text{Ore}}{yFe_2O_3} + \underset{\text{Lime}}{zCaO} + \underset{\text{Scrap}}{uFe}} = \frac{(17.7Fe + 0.8C + 0.1Si)}{\text{Finished steel}} + \frac{(3x - 0{\cdot}8)\,CO}{\text{Carbon monoxide disengaged}} + \frac{x(0.5SiO_2 + 0.2MnO + 0.6CaO + 0\,6FeO + 0.1P_2O_5 + 0.4CaO)}{\text{Slag}}$$

Taking, for instance, x as being equal to two-thirds, we deduce from the preceding equation the following proportions as corresponding to the production of one ton of steel:

	Kilogrammes. Theory.	Practice.	
Pig iron.....	667	670	
Fe_2O_3.....	145.70	210	(75 per cent)
Lime.....	40.90	45	
Scrap.....	267.68	285	

Consumption of energy:

a—Heating bath of pig iron,

$q_a = 670 \times 0.48 \times 450 = 144{,}700$ calories.

b—Heating the reagents,

$q_b = (210 \times 0.19 + 45 \times 0.23) \times 1600 = 80{,}400$ calories.

c—Chemical reactions,

$q_c = 48{,}900$ calories.

d—Fusion and heating of the iron,

$q_d = 285\ (410 + 0.48 \times 240) = 149{,}700$ calories.

e—Radiation losses,

$q_e = 5lc\theta$ watt-hours.

For a furnace of W kilowatts, producing P kilogrammes of steel for each run of θ hours, we have—

$$W\theta = 480P + 5lc\theta \quad . \quad . \quad (12)$$

By taking the same calculations as the preceding case, we have—

$$l = 12200 \sqrt{\frac{P}{W}} \qquad (13)$$

$$c = 0.53 \sqrt[4]{PW} \qquad (14)$$

$$lc = 1863 \sqrt[4]{\frac{P^3}{W}} \qquad (15)$$

$$W\theta = 480P + 9315 \sqrt[4]{\frac{P^3}{W}} \qquad (16)$$

By taking the value of $\theta = 3$, the equation may now be written—

$$W = P\ (160 \times 9315 \sqrt[4]{\frac{1}{PW}} \qquad (17)$$

From these equations we may construct the accompanying curves.

COST OF PRODUCTION OF ELECTRIC STEEL.

In order to determine the cost of production of the steel, we will suppose that the electrical furnaces receive the pig iron direct from the blast furnace. These calculations have been based upon an annual production of 30,000 tons of 2,204 pounds each.

	Kilogrammes. Ore Process.	Mixed Process.
Pig iron	925	670
Scrap iron	—	285
Iron ore (75 per cent)	320	210
Lime	56	45

Following the preceding calculations, and supposing electric furnaces of 650 kilowatts, there would be expended—

	Ore Process. Kw.-h.	Mixed Process. Kw.-h.
Electric furnace (30,000 tons)	16,200,000	18,000,000
Machinery and appliances	2,640,000	2,400,000
Total	18,840,000	20,400,000
	Kw.	Kw.
For 8,000 hours' annual operation	2,355	2,550
Or, allowing for losses and hindrances of all sorts	2,400	3,700

The following are particulars of cost of production based upon French prices of cost of materials, labor, etc.

ORE PROCESS.

ANNUAL BUDGET OF EXPENSES.

I. Office and management charges ... £2,800

II. Raw materials and fuel.

a. Production of the pig iron.

Ore .....48,000 tons at £0 10 0 = £24,000.
Furnace slag, 4,400 tons at £0 2 5 = £528.
Slags, various, 4,400 tons at £0 3 6 = £770.
Waste .....2,250 tons at £1 14 0 = £3,825.
Flux.....£13,400 tons at £0 4 6 = £3,015.
Coke.....£30,500 tons at £0 16 0 = £24,400.
Sundries..... .....£462 — £57,000

b. Conversion into steel.

Ore ..... 9,600 tons at £0 10 0 = £4,800.
Lime .....1,600 tons at £0 12 6 = £1,000.
Iron alloys.....300 tons at £10 0 0 = £3,000.
Chromite of iron, 160 tons at £4 10 0 = £720.
Sundries.....£380 — 9,900

III. Electrical energy.

2,400 kilowatt-years at £3 10 0 ..... £8,400

IV. Labor.

Day shift, 55 men; night shift, 46 men; 36,000 days at 5s £9,000

V. Maintenance and repairs.. ..... £3,000

VI. General and incidental charges 2,900

£93,000

Say per ton of steel produced, £3 2s.

MIXED PROCESS.

ANNUAL BUDGET OF EXPENSES.

I. Office and management charges... £2,800

II. Raw materials and fuel.

a. Production of the pig iron.

Ore .. .. .35,000 tons at £0 10 0 = £17,500.
Furnace slag, 3,200 tons at £0 2 5 = £375.
Slags, various, 3,200 tons at £0 3 6 = £560.
Waste..... 1,600 tons at £1 14 0 = £2,720.
Flux.....10,000 tons at £0 4 6 = £2,250.
Coke..... 22,000 tons at £0 16 0 = £17,600.
Sundries..... £395 — 41,400

b. Scrap iron.

8,500 tons at £2 2s. £17,850

c. Conversion into steel.

Ore..... 6,300 tons at £0 10 0 = £3,500.
Lime.... .....1,300 tons at £0 12 6 = £760.
Iron alloys ....300 tons at £10 0 0 = £3,000.
Chromite of iron, 160 tons at £4 10 0 = £720.
Sundries..... £420 — £8,400

III. Electrical energy.

2,700 kilowatt-years at £3 10s. £9,450

IV. Labor.

34,000 days at 5s £8,500

V. Maintenance and repairs..... 2,800

VI. General charges and incidentals. .. 2,800

Total £94,000

Say per ton of steel produced, £3 2s. 8d.

A plant of 1,200 horse-power is actually constructed at Plattenberg on the Lenne (Westphalia), and will commence to operate in a few months.

CONCLUSIONS.

In order to avoid the accusation of undue optimism, the preceding estimates, it is claimed, have been based upon prices sufficiently high, and the electrical energy can easily be had at the price calculated ($16 per kilowatt-year).

A combination of conditions more favorable would reduce still further the cost of production. It is not difficult to imagine a company having minerals at $2.60 per ton, and proprietor of hydraulic power. Under such circumstances the electrical energy would be available at $8 per year per kilowatt, which would still further reduce the cost per ton of finished steel.

Shopping by Telephone.

The department store of Marshall Field & Company, Chicago, Ill., is celebrated for its many modern contrivances for the facilitation of business. A noteworthy installation is the telephone service, which is said to be the largest private telephone exchange in the United States. Over 300 telephones are used in this immense establishment. On every floor, and serving each separate department—the department being further subdivided into aisles—are located telephone instruments by which the shopper can communicate with the outside world at a moment's notice. The company operates its own exchange and has an extensive intercommunicating system. The apparatus is leased and the talking current furnished by the Chicago Telephone Company.

A very modern feature of this service is the provision by Marshall Field & Company of expert shoppers, who may be called upon, through the medium of the telephone, to execute purchases for out-of-town or local patrons who find it impossible to make the trip to the store.

Mr. Angus Hibbard, the vice-president and general manager of the Chicago Telephone Company, is very proud of this exchange. He points to it as one of the show features of the company's plant, and finds great satisfaction in the quality of service which it gives to Marshall Field & Company.

Measurements of Small Inductances.

Dr. J. A. Fleming, in a recent note to the British Physical Society, states that he has obtained very good results in the measurement of small inductances by Anderson's method, using a telephone in place of a galvanometer and a buzzer of the battery circuit. Dr. Fleming has found that for long solenoids at least fifty diameters in length, the inductance can be calculated with an accuracy of about one per cent, by the rule that the inductance, in centimetres, is equal to the length of wire per unit length of solenoid, multiplied by the total length of wire in the whole solenoid, in centimetres. It was also found that Anderson's method is suitable for measuring small capacities, such as those of the Leyden jar.

The Electric Power Station of the New Richmond Roller Mills Company.

By R. D. Thomas.

A SMALL hydroelectric plant, which has many interesting features, has recently been installed on the Apple river, Wisconsin, by the New Richmond Roller Mills Company, in connection with its flour mill and elevator which are located in New Richmond about five miles distant from the generating station. New Richmond is situated on the Willow river, which formerly supplied enough water power to operate the mill, but as the output of the mill increased this small water power proved insufficient and so a 200-horse-power induction motor was installed, taking current from the lines of the Apple River Power Company. As this source of power at times proved unreliable, the company, in the fall of 1901, began to seek for a means of supplying themselves with power from the Apple river. A good dam site was located near Huntington, Wis., which is but a few miles distant from New Richmond.

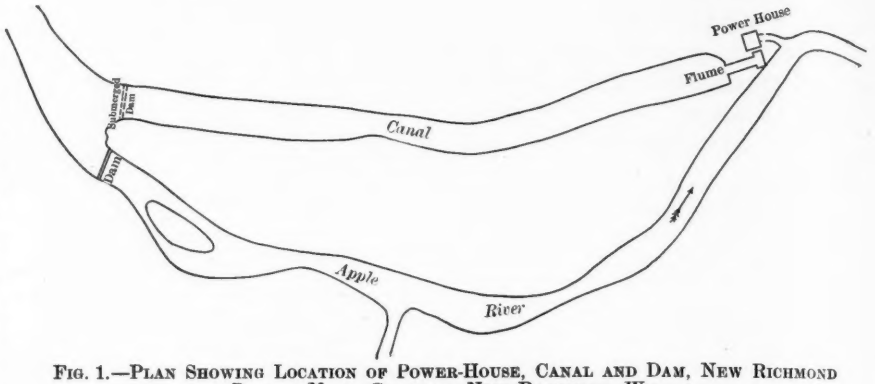


FIG. 1.—PLAN SHOWING LOCATION OF POWER-HOUSE, CANAL AND DAM, NEW RICHMOND ROLLER MILLS COMPANY, NEW RICHMOND, WIS.

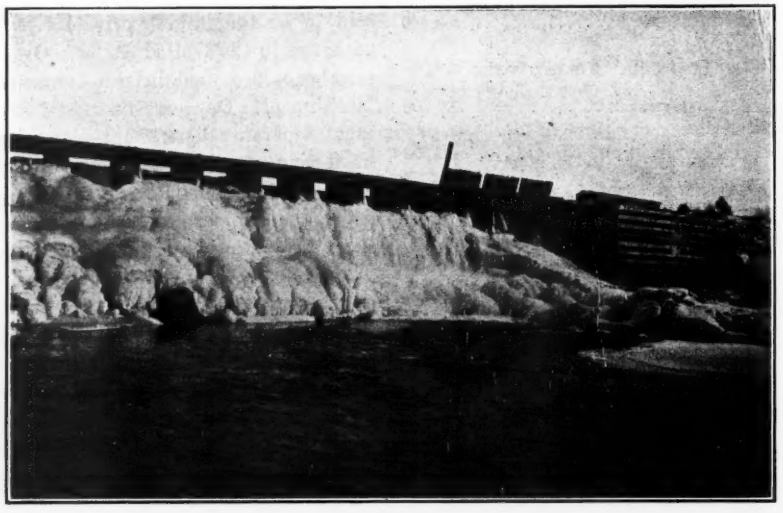


FIG. 2.—DAM FROM BELOW, SHOWING ABUTMENT AND WALK OVER DAM FOR HANDLING FLASH BOARDS.

The Apple river is fed mainly by springs, thus assuring a very uniform flow varying at the dam site from an ordinary low stage in winter of 210 cubic feet per second to 270 cubic feet per second, the ordinary summer stage. Preliminary plans and surveys showed that a head of fourteen feet was available at this site, but that this could be increased to twenty-seven feet by placing the power-house about 2,200 feet down stream, leading the water from the mill pond through a canal and flume, as shown in plan in Fig. 1. This additional thirteen feet of head was gained at a very moderate increase in cost because of the small amount of necessary excavation.

The plant as built consists of a stone-filled timber crib dam, a canal, an open timber flume and penstock, and the power-house. A river bed of coarse gravel and sand made a good foundation for the dam without the need of excavation. On this gravelly bottom a brush mattress fifty feet long was first placed, laid parallel with the stream. This mattress was covered with logs, and the whole was weighted down with stones. To the logs was drift-bolted the timber cribbing. Then, as the building progressed, stones taken from the bottom of the river were filled in and the water was allowed to flow through, which made it possible to continue the work without coffer-dams. After the dam was raised to the proper elevation gravel and

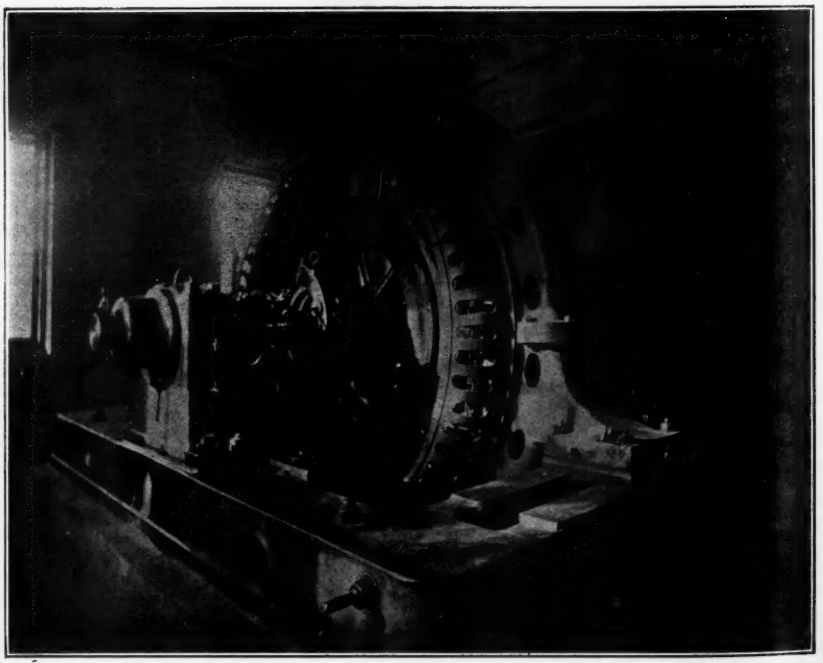


FIG. 4.—DIRECT-CONNECTED GENERATOR, 400-KILOWATT, 6,600-VOLT, THREE-PHASE.

sand were placed in the river on the upstream side, making it eventually watertight.

The elevation of the pond is raised three or four feet above the crest of the spill-way by means of flashboards, which are easily handled from a walk overhead. As the water is never expected to rise to this walk, a permanent means of communication from one shore to the other is thus provided.

The dam and walk are shown in Fig. 2.

At the entrance to the canal is a submerged dam, which provides for its be-

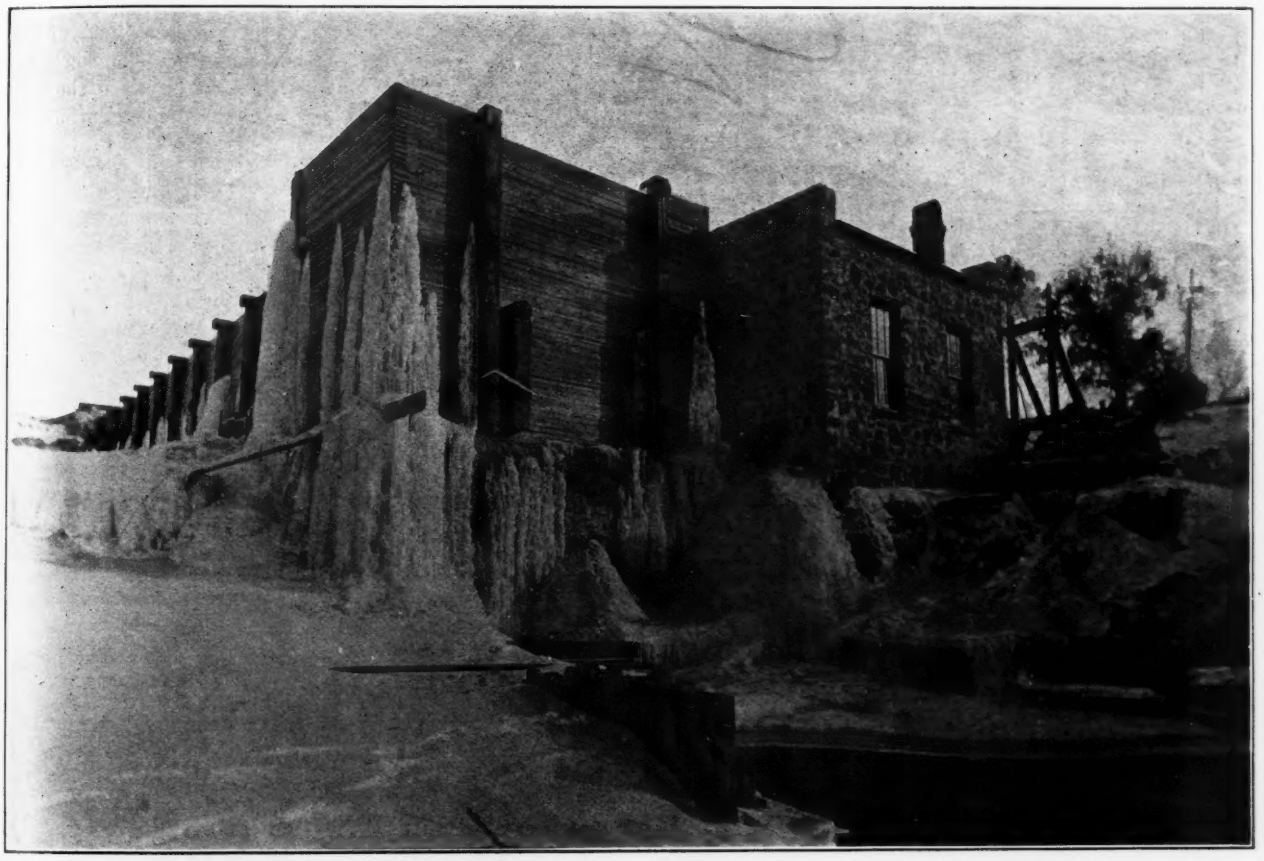


FIG. 3.—NEW RICHMOND ROLLER MILLS COMPANY'S POWER-HOUSE, PENSTOCK AND FLUME, FROM BELOW.

ing emptied by lowering the water in the pond to a point below the crest of this dam and then draining the canal through the water-wheels. Owing to the great width of the canal and consequent low velocity of the flow, it was not deemed necessary to construct regulating gates at the lower end.

The canal is built on a bench having on one side the natural embankment and on the other side an embankment built of the excavated material from the middle. An open timber flume 112 feet long leads from the lower end to an open penstock ten feet square, on the floor of which are set the water-wheels, the water flowing ordinarily about eight feet deep over the floor of the flume and about eleven and one-half feet over the centre of the turbine shaft. Barks, snags and other debris are kept from the wheels by means of a rack built of three and one-half by one-quarter-inch flat iron bars spaced one and three-quarter inches by means of cast-iron thimbles, which rack is placed at the entrance to the penstock. A view of the penstock with a part of the flume, taken from below, is shown in Fig. 3.

There are no gates at the entrance to the penstock, but the water can be shut off by means of stop logs placed at the head of the flume.

The water-wheel equipment consists of one pair of thirty-five-inch twin Samson wheels built by the James Leffel Company of Springfield, Ohio. These wheels are guaranteed to develop 675 horse-power under twenty-seven foot head. The middle bearing is supported by a heavy bridge-tree in the centre of the wheel-case which, in turn, is bolted to a cast-iron base resting on the penstock floor. To the bottom of this base is riveted an eight-foot draft-tube of the elbow type, which discharges the water into the tail-race in the proper direction. Observations in the tail-race while the plant is in operation shows that there is absolutely no turmoil, and that the water leaves the wheel-pit with practically no velocity.

The end bearings of the turbine shaft are supported by cast-iron pedestals. One end of the shaft passes through a stuffing box in the penstock wall into the generator room where it is fitted with a heavy flanged coupling connecting it directly to the generator shaft.

The power-house is built on a foundation of concrete in which large boulders found on the ground are imbedded. The walls are of rubble masonary laid in cement. Fig. 4 shows the generator which is a 400-kilowatt, 6,600-volt, three-phase, revolving field. The Westinghouse alternator sets on a heavy concrete base.

The generator runs at 240 revolutions per minute, supplying current at sixty cycles per second. Regulation is maintained by means of a Woodward governor, together with a very interesting device in connection with the exciter. See Fig. 5, which a diagram of this arrangement. The fifteen-kilowatt direct-current exciter has three separate field windings, namely, a shunt winding and a series winding, both of which are self-excited, and in

addition another winding which is excited by a current from a small commutator placed on the generator shaft. This rectified current always bears a certain ratio to the total alternator current, except in

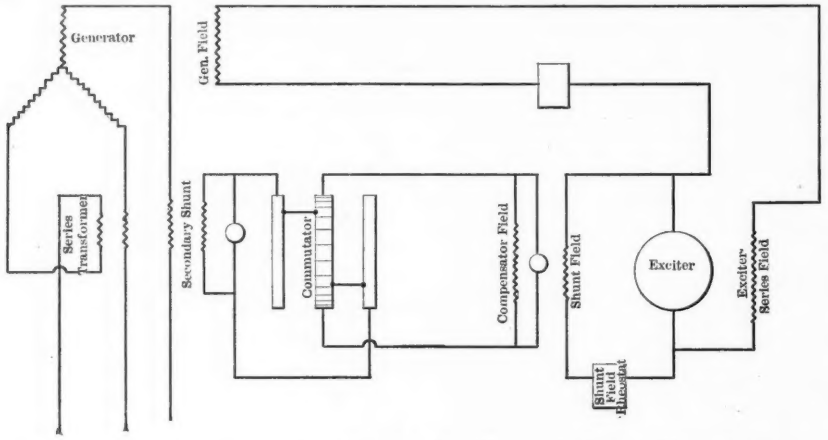


FIG. 5.—DIAGRAM OF COMPENSATING DEVICE, NEW RICHMOND ROLLER MILLS COMPANY.

so far as it may be affected by the varying power-factor, but the brushes on the small commutator are set at such an angle that as the current lags in phase the points of maximum voltage will approach the brushes, so that the rectified voltage will also increase as the power-factor decreases. This makes it possible to maintain a constant voltage at the delivery end of the line under the most severe conditions of load and power-factor. For an illustration of the efficiency of this arrangement the load was suddenly changed from 170 kilowatts and a power-factor of eighty-six to forty kilowatts with a power-factor of sixty-two with scarcely any variation of the voltage on the switchboard and but a momentary fluctuation noted on a Bristol recording meter at the mill. This contrivance makes the plant practically self-operating and it has, in fact, run for consecutive days of twenty-four hours each without any regulation from the switchboard. It is a very simple affair and should it get out of order it can be cut off from the circuit and the plant operated without it until repairs can be made. The exciter and the governor are both bolted to the generator shaft.

The lightning arresters, three in number, are what is known as the "low equivalent" type. This lightning arrester is so constructed that it affords an easy path for the lightning discharge to pass to earth and at the same time prevents the generator current from following. It consists essentially of a series of short spark-gaps placed in series with resistance. A number of gaps adjacent to the grounded terminals are also shunted by resistance. This brings the point, to which the shunt resistance is connected, to the ground potential and, therefore, reduces the number of gaps over which the lightning discharge must leap in the first place. However, when an arc is established over the first set of gaps the shunt resistance is insufficient to carry the lightning discharge, so that a sufficient difference of potential is established over the shunted gaps to cause the discharge to leap across. When the line is discharged, the generator current following is withdrawn from the shunted gap by the shunt resistance, which has the effect of reducing the current, so that the series gap can readily suppress the arc. A choke coil is interposed between the lightning arrester and the apparatus to be protected. The choke coil, on account of self-induction, has the effect, as is well known, of preventing the passage of any sudden flow of current as that caused by a lightning discharge. Fig. 6 is a view of the switchboard, which consists of one panel with three ammeters, one indicating wattmeter, one recording wattmeter, and two alternating-current voltmeters.

The transmission line consists of three No. 4 hard drawn copper wires carried on glass insulators, supported by Carolina locust pins twelve inches long and two and one-quarter inches diameter in the hole. The wires are placed at the apexes of an equilateral triangle eighteen inches on each side. The poles are of selected Wisconsin cedar with the least diameter at the top of eight inches and of varying lengths to suit the topography of the country, the aim being to make the wires as nearly level as possible. The tops of the poles were coated with asphaltum and the pins and pin holes were given a coating of tar. The poles are spaced 110 feet apart. A telephone line is run on the transmission pole line four feet below

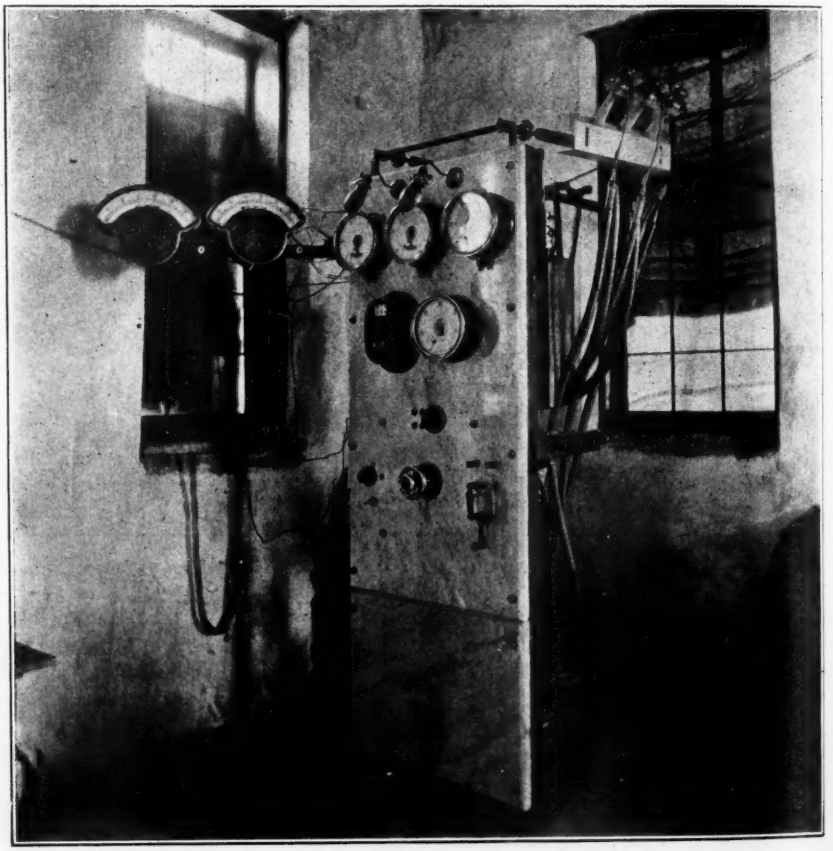


FIG. 6.—SWITCHBOARD, POWER PLANT, NEW RICHMOND ROLLER MILLS COMPANY, NEW RICHMOND, WIS.

the lower transmission wires. These telephone wires are of No. 9 galvanized iron and are transposed at every fourth pole, whereby all disturbing influences due to induction are avoided.

Four seventy-five-kilowatt, oil-insulated transformers receive the three-phase current from the line at the delivery end and deliver a two-phase, 200-volt current to a 200-horse-power, standard induction motor which in turn is belted to the line shafting of the flour mill. This type of motor seems to be particularly suitable for a flour mill where so much dust is present, as the absence of brushes, commutator and other moving contacts prevents flashes or arcs, thus avoiding this possible source of fire. Two similar motors of fifty horse-power and twenty horse-power, respectively, are in use at the elevator connected with two transformers of the same type as those in the mill.

This plant was designed by Mr. J. W. Rickey, of Minneapolis. The entire electrical equipment was furnished and installed by the Westinghouse Electric and Manufacturing Company. The plant has now been in successful operation since the first of December, 1903.

A Hot-Wire Ammeter for Measuring Very Small Alternating Currents.

In a note to the British Physical Society, Dr. J. A. Fleming describes a type of hot-wire ammeter which does not involve the use of iron, and is capable of measuring alternating currents as small as two one-thousandths of an ampere. Two fine platenoid or constantine wires, about a metre in length and 0.05 or even 0.02 millimetre in diameter, are supported on a wooden rod, with arrangements for adjusting their tensions. They are five millimetres apart, and are held down at the centre by delicate spiral springs.

The two wires are embraced at the middle by a small loop of paper carrying a very small plane mirror. The whole is enclosed in a box, the lid of which carries a lens, by means of which a beam of light is thrown upon it. Upon passing a current through one of the wires, it sags slightly, and the square root of the displacement of the spot of light on the screen is nearly proportional to the current flowing.

The instrument is easily calibrated, if the resistance is known, by applying a known voltage to the ends of the wire. Wires should be aged by passing an intermittent current through them for several hours before they are put in use.

THE ALUMINUM ELECTROLYTIC CONDENSER.[1]

BY C. I. ZIMMERMAN.

INTRODUCTION: ASYMMETRICAL CELLS—THE FILM.

The property of asymmetrical conductivity which is possessed by many electrolytic cells may in some instances be developed to a remarkable degree. An illustration of such cells is one with aluminum and carbon electrodes in an aqueous solution of ammonium phosphate. This cell will allow a current to pass freely when the carbon is the positive terminal and will prevent the passage of a current when the aluminum is the positive terminal.

The asymmetrical effect of the aluminum cell is located in the thin film which is formed upon the surface of the aluminum electrode by electrochemical oxidation. This film under ordinary circumstances firmly adheres to the surface of the metal, no matter in which direction the current flows through the cell. Its composition can not be definitely determined, since sufficient quantities can not be collected to be given an accurate analysis. It is believed to be some form of oxide, or, perhaps, hydroxide of aluminum.

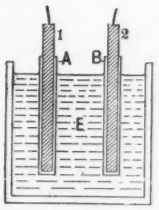


FIG. 1.—ALUMINUM CONDENSER.

The principal factors affecting the growth of a film are the kind of electrolyte, the value of the impressed pressure, the duration of the process of formation and the temperature of the electrolyte. Either alternating or direct currents may be used for the formation, since reduction of the film does not occur to an appreciable extent when current flows toward the aluminum plate.

When first formed, the film in itself is ordinarily transparent and colorless. Its presence is best detected upon smooth plates by the interference colors which are produced in light reflected from the surface.[2] After a short usage the electrode becomes grayish, but the bright colors are not necessarily destroyed. The grayish appearance is due to a slight roughness of the metallic surface beneath the film, and to the presence of numerous minute punctures in the film.

By means of these interference color phenomena the writer has estimated the thickness of the films. They range from less than 0.000005 centimetres to, in exceptional cases, more that 0.000050 centimetres in thickness.

THE CONDENSER.

This extremely thin asymmetrical layer exists between two electrical conductors and it constitutes an asymmetrical dielectric which may be considered capable of holding positive charges only on the side in contact with the metal, and negative charges only upon the side in contact with the liquid. The disruptive strength of this film when the metal is positive to the electrolyte is apparently greater than that of mica. Its specific inductive capacity is not unity, as has been assumed by some,[1] if we calculate it from the electrostatic capacity of a given electrode and the thickness of the film as estimated by the color phenomena. On the other hand, the specific inductive capacity seems to be abnormally high for a solid. Mr. W. R. Mott[2] in investigating the aluminum anode properties, calculated the dielectric constant of the film to be in the neighborhood of eighty.

THE ALTERNATING-CURRENT CONDENSER.

An electrolytic cell having both electrodes of these coated aluminum plates will obviously prevent a direct current from flowing continuously through the cell in either direction. An alternating pressure, on the other hand, causes a comparatively large current to flow; the current being a leading or condenser current. A cell of this type (see Fig. 1) constitutes the simplest form of an aluminum electrolytic condenser for alternating-current circuits.

It must be borne in mind that these asymmetrical properties are properties of the chain: metal-film-electrolyte. When dry, the film acts like any ordinary dielectric. When the aluminum electrode is immersed in the electrolyte, it is not a perfect asymmetrical conductor or dielectric. In the discussion to follow, perfect asymmetry, no polarization pressures and no cell losses are assumed to exist. These conditions are only approximated, as will be shown.

In Fig. 1, 1 and 2 represent two similar cell electrodes of metallic aluminum, coated by the thin films A and B, and

[1] Abstract of paper read at the meeting of the American Electrochemical Society, Washington, D. C., April 8, 1904.

[2] W. Beetz, *Journal der Physik*, vol. clvi, p. 456, 1875. "Poggendorff's Annalen," vol. ccxliv.

[1] A. Noden, *Comptes Rendus*, vol. cxxxvi, p. 445-446, 1903.

[2] Thesis, University of Wisconsin, 1903.

immersed in the electrolyte E. The electrolyte E is one which is capable of maintaining the continuity of the film by electrochemical oxidation. The films A and B are the two dielectrics which, it must be remembered, will allow the current to flow from the electrolyte to the electrodes, but not in the reverse direction, and which can hold positive charges only next to the metallic conductors, and negative charges only next to the electrolytic conductor.

If the cell be connected into the circuit when the alternating pressure is passing through zero and when electrode 1 is becoming positive to electrode 2, a current will flow in the entire circuit in the direction from electrode 1 toward electrode 2. Film A receives an electrostatic charge whose potential rises to that of the pressure upon the cell terminals, for film B allows the free passage of current out of the cell.

When the impressed pressure ceases to increase, the current in the circuit stops flowing. As the impressed pressure begins to decrease, film A tends to discharge itself into the circuit. Electrode 2 now becomes the anode and film B receives an electrostatic charge, positive on the side next to the metal and negative on the side in contact with the electrolyte.

Whatever may be the subsequent variation of pressure upon the cell terminals, the coulomb charge removed from either one of the films must collect upon the other; and we have, consequently, a condenser in which the total charge in coulombs remains constant. This statement assumes that the subsequent pressures upon the cell terminals do not rise higher than the maximum value of the pressure which caused the charge to collect in the cell.

This constant charge may be observed in the aluminum cell by disconnecting the cell from the alternating pressure circuit, short-circuiting the electrodes, and then connecting a voltmeter to the short-circuiting wire and to a carbon rod dipped into the electrolyte. A discharge always occurs through the voltmeter from the metallic connections to the electrolyte. The short-circuiting of the cell is equivalent to removing the cell from the circuit when the alternating pressure passes through zero. Under similar circumstances, an ordinary condenser is completely discharged.

A given coulomb charge q, removed from one of the films as A, lowers the potential difference across the two sides of that film by a definite amount as e. This same charge in becoming stored up in the other film raises its potential by the same amount e, if the two films have equal electrostatic capacities. The arithmetical sum of the pressures across the two films is thus constant. The value of this sum is equal to the maximum value of the pressure applied to the cell terminals.

These two film pressures are in opposition to one another. The algebraic sum

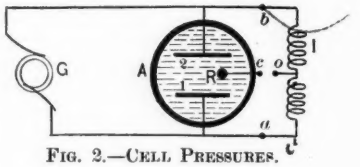


FIG. 2.—CELL PRESSURES.

of their instantaneous values is equal to the instantaneous value of the impressed pressure.

The short-circuiting of the electrodes of an aluminum condenser allows an equal distribution of the charge upon the two plates to occur.

This constant electrostatic charge remaining in the cell at all times sets up a difference of potential between the inside of the cell, or the electrolyte, and a point outside of the cell (in the metallic con-

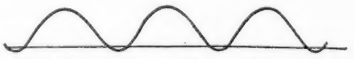


FIG. 3.—PRESSURE ON FILM, OSCILLOGRAPH CURVE.

nections) which is neutral to the alternating pressure.

The middle point of an inductance coil placed across the cell terminals represents such a point. In Fig. 2, an alternator G is shown connected to the terminals of an aluminum condenser A. An inductance coil I is placed across the cell terminals. By means of a carbon rod R, dipped into the electrolyte, the potential of the electrolyte may be obtained. The polarization pressure that is set up at the surface of this carbon terminal will be

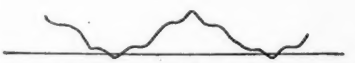


FIG. 4.—PRESSURE ON FILM, OSCILLOGRAPH CURVE.

assumed for the present to be zero, as it is small compared with the generator pressure.

The pressure between the middle point o of the inductance coil and the electrolyte c is a uniform direct pressure, as was explained above. The pressure across one-half the inductance coil is one-half the alternating pressure. The pressure between the electrolyte c and either of the cell terminals a or b is the resultant of a uniform pressure of a magnitude equal to one-half the maximum instantaneous value of the pressure wave impressed upon the cell, and an alternating pressure of a magnitude equal to one-half the effective value of the pressure impressed upon the cell. With an effective sinusoidal alternating pressure E, this resultant is theoretically equal to $\frac{\sqrt{3}}{2}$ E or 0.866 E.[1]

The average value of the pulsating pressure wave is dependent only upon the maximum instantaneous value of the impressed pressure wave. The average value for a sinusoidal impressed pressure wave is $\frac{E}{\sqrt{2}}$ or 0.707 E. These pulsating unidirectional pressures upon each film are continuous sinusoidal waves with an amplitude of one-half the alternating wave across the cell terminals, a maximum value equal to the maximum of the alternating wave and a minimum value which is zero.

The average and the effective values of these waves may be measured by means of direct and alternating-current voltmeters respectively. The results obtained by such measurements are lower than the theoretical values, due, as was previously mentioned, to the film not being a perfectly asymmetrical conductor, to polarization pressures existing at the aluminum and carbon electrodes, and to the small energy losses in the cell. With 100 effective alternating volts applied to the aluminum terminals, the readings obtained by alternating and direct-current voltmeters are about seventy-seven and 60.5 respectively, the theoretical values being 86.6 and 70.7.

The pulsating pressures upon the films are shown in Figs. 3 and 4 in curves taken directly from Blondel oscillograph records. The impressed pressures were similar in shape to these waves. Their amplitudes were twice as great and they were symmetrically disposed with respect to the straight line. The curves are observed to cross the zero line slightly, due to imperfect asymmetry, polarization pressures, cell losses, and to the effect of the oscillograph in removing a portion of the charge in the cell.

In Fig. 5 are shown oscillograph curves of all the cell pressures and also the charging current of a forty-microfarad condenser, superimposed upon one another. The impressed pressure was 100

[1] $\sqrt{(\text{eff. D. C.})^2 + (\text{eff. A. C.})^2} = \sqrt{\left(\frac{E}{\sqrt{2}}\right)^2 + \left(\frac{E}{2}\right)^2} = \frac{\sqrt{3}}{2} E.$

volts and of a triangular shape. Curve *b-b* is the impressed pressure referred to *a-a*, *c-c* is the pressure between one of the cell terminals and the electrolyte referred to *a-a*, and *d-d* is the pressure between the other cell terminal and the electrolyte as seen by the oscillograph. The charging current of the condenser *i-i* is flat-topped because the pressure wave is triangular in shape.

VARIATION OF THE ENERGY WITHIN THE CELL.

The condenser action of this cell is to be found in the energy variation resulting from the variation of the distribution of the constant coulomb charge within the cell. The following discussion will illustrate the point:

Let E_M be the maximum value of the alternating pressure and Q be the charge in coulombs which one of the films receives due to the potential difference E_M. The charge upon the second film is zero, as was shown previously, when the first film has its maximum charge.

The energy W_1 stored up in the condenser at the instant of maximum pressure is

$$W_1 = \frac{1}{2} QE_M$$

When the impressed pressure passes through zero, each film holds one-half the charge, at one-half the pressure E_M, and the energy W_2 stored up in the condenser is

$$W_2 = 2\left(\frac{1}{2} \times \frac{Q}{2} \times \frac{E_M}{2}\right) = \frac{1}{4} QE_M$$

or one-half as much as at the time of maximum pressure. The variation is

$$W_1 - W_2 = \frac{1}{4} QE_M,$$

which is one-half the total energy stored up when the impressed pressure is at its maximum.

COMPARISON WITH TIN-FOIL CONDENSERS.

Since, with a sinusoidal pressure wave impressed, the pressures upon the two dielectrics vary sinusoidally, it follows that the condensers charging current is sinusoidal and likewise the energy variations in the circuit. The aluminum condenser thus has the same condenser effect upon a circuit that an ordinary tin-foil condenser has.

An aluminum condenser periodically absorbs and returns only one-half the total amount of energy it stores up. This charge is held upon one film only at the time of maximum charge. Consequently the effective electrostatic capacity of a condenser as figured from its sinusoidal charging current is but one-half the electrostatic capacity of one of its films. A tin-foil condenser absorbs and returns its total energy charge, and its charging current is proportional to the full electrostatic capacity of its film.

In a certain sense the aluminum condenser may be considered to be like two tin-foil condensers of equal capacities placed in series, for the pressures upon each film have an alternating component equal to one-half the alternating pressure

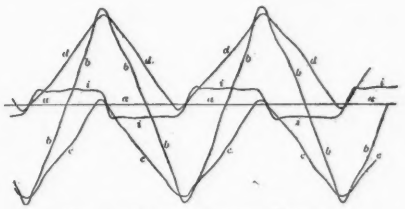


FIG. 5.—OSCILLOGRAPH CURVES.

upon the condenser; and, again, the effective electrostatic capacity of an aluminum condenser is one-half the electrostatic capacity of either film. However, each film of the aluminum condenser is subjected to nearly the maximum pressure upon the cell instead of but one-half the maximum as in the ordinary condensers; and either film becomes charged while the other becomes discharged, instead of being charged and discharged together as in the two tin-foil components.

The charging current of both aluminum and tin-foil condensers is a function not only of the pressure and fundamental frequency of the impressed pressure wave, but a function of the irregularities or higher harmonics in the pressure wave as well. Fig. 6 shows the amplification of the charging current I produced in an aluminum condenser by the irregular pressure wave E. At each of the maxima

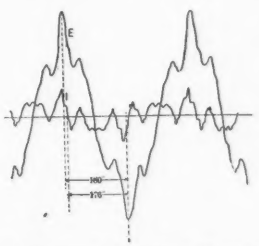


FIG. 6.—CHARGING CURRENT PRODUCED BY IRREGULAR PRESSURE.

and minima in the pressure wave, the condenser current passes through zero, for at these instances the rate of change of the pressure is zero. The current is greatest where the wave is the steepest; *i. e.*, where the rate of change of the pressure is greatest. The effective value of the current as measured by a Hoyt instrument was 2.4 times the value calculated for a sinusoidal pressure wave of an equal impressed pressure (114 volts) and a frequency of the fundamental wave (sixty periods per second). The condenser upon which these curves were observed had a capacity equivalent to a forty-microfarad tin-foil condenser.

THE LOSSES IN THE ALUMINUM CELL.

The losses of the aluminum cell consist of the following:

1. Film losses.
2. C^2R losses.
3. Electrolytic decomposition losses.

The film losses are the principal losses in the cell and they include A leakage losses and B a loss proportional to the frequency. The leakage losses are due to minute local breakdowns of the film and to an apparently uniform passage of current through the high-resistance film by conduction. These losses (those due to the minute punctures of the film in particular) increase rapidly when the pressure upon a given film goes beyond a certain point which has been termed the breakdown point. The point of breakdown is dependent largely upon the kind and temperature of the electrolyte, as well as upon the thickness of the film. By obtaining suitable conditions the writer has recently succeeded in operating simple two-electrode condensers directly upon effective alternating pressures as high as 1,250 volts without disrupting the dielectrics.

The losses proportional to the frequency are of a nature not yet clearly understood. With the higher commercial frequencies (60 to 130 cycles per second) they are in general greater than the other losses in the cell.

The C^2R losses of the electrolyte may be reduced to a negligible quantity by intermeshing sheet electrodes of opposite polarity. The electrostatic capacity per unit of surface is, fortunately, not so great as to cause the current density to be high. The enormous capacities per unit of surface in the so-called "polarization condensers" is one of their inherent practical disadvantages.

The losses caused by electrolytic decomposition are those due to the leakage current only. The wattless condenser current is induced in the electrolyte electrostatically. The products of decomposition may be made to consist chiefly of minute quantities of hydrogen and oxygen.

The presence of a breakdown point in the aluminum cell, at which the losses begin to rapidly increase, is a particularly valuable property of the aluminum condenser, because the dangerous temporary rises in voltage that tend to occur through

resonance are thereby practically prevented.

It is not of any serious consequence to scratch the electrode, for any break in the film is quickly repaired by electrochemical oxidation. Punctures due to abnormally high voltages are for the same reason of little consequence unless the puncturing be long continued.

In general it may be stated that the voltage limit for single cells is not much above 150 volts where high efficiencies are desired. The efficiencies may range from less than ninety-three per cent to as high as ninety-seven per cent, according to the operating conditions. It is possible to operate condensers continuously at efficiencies above ninety-five per cent with pressures at 110 volts.

The weight, volume and cost per microfarad of single cell electrolytic condensers are considerably smaller than for equivalent tin-foil condensers operating at the same voltages. This great difference is not so marked where the voltages rise much beyond those at which single condensers can operate efficiently, since the energy-storing value of a condenser varies as the square of the pressure upon its terminals.

The electrostatic capacity for 110-volt aluminum condensers may be said to be roughly one-quarter to one-half microfarad per square inch of aluminum plate in the cell.

Long Life of an Incandescent Lamp.

A sixteen-candle-power incandescent lamp, made by Kotknisky, installed in a mill at Manderscheid, has been in operation since 1892, about 1,250 hours per year. It is still in good condition and giving a good light, although it has been burning for 14,000 hours. It is fed from a continuous-current system. Another instance of long life is that of a lamp in the Carlsruhe municipal station. This is a Siemens & Halske thirty-two-candle-power 120-volt lamp, fed by an alternating current. It was installed on June 16, 1901, in an underground gallery, placed in a horizontal position. The manager of the station estimates that up to the sixteenth of December, 1903, it had burned 21,800 hours. However, this lamp was consuming, on that date, ninety-eight watts, and its intensity was only nine candles, being about eleven watts per candle. It is thought that these two examples show that the kind of current used has not influenced the life of the lamp.—*Revue Pratique de l'Electricité* (*Paris*), *April* 5.

HYDRAULIC ANALOGY OF THE ALUMINUM ELECTROLYTIC CONDENSER.

BY C. I. ZIMMERMAN.

The hydraulic analogy of the behavior of the ordinary tin-foil condenser is shown in Fig. 1. M is an elastic membrane and

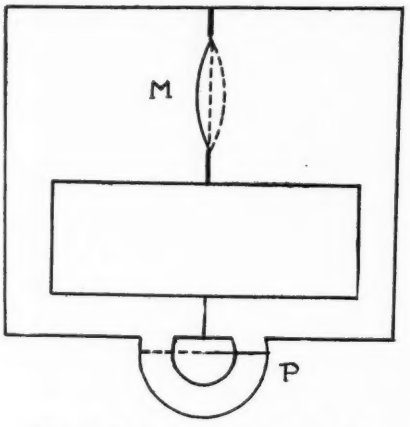


FIG. 1.—HYDRAULIC ANALOGY OF TIN-FOIL CONDENSER.

P is a pump which causes the liquid to move back and forth in the hydraulic circuit.

Two tin-foil condensers in series are represented in Fig. 2.

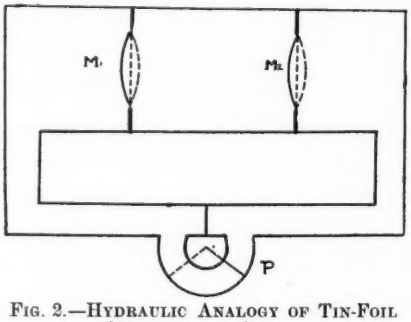


FIG. 2.—HYDRAULIC ANALOGY OF TIN-FOIL CONDENSER IN SERIES.

The aluminum condenser is represented in Fig. 3. The films or dielectrics here consist of elastic membranes and valves. The valves allow liquid to flow out of the middle compartment (the electrolyte) but

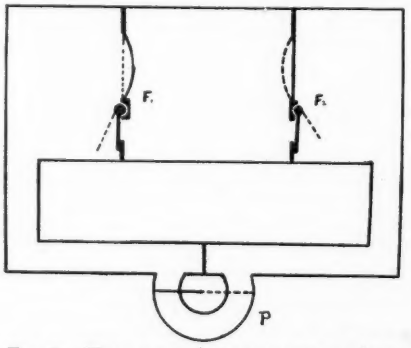


FIG. 3.—HYDRAULIC ANALOGY OF THE ALUMINUM ELECTROLYTIC CONDENSER.

not into it. Both valves remain closed after one of the membranes has been stretched to the maximum value. The membranes are stretched alternately and always toward the middle compartment.

WIRELESS TELEGRAPH WAR SERVICE.

AN INTERVIEW WITH MR. FRANCK Z. MAGUIRE CONCERNING THE WORK OF THE DE FOREST WIRELESS SYSTEM.

"To outwit the censor and to get the news are the essential points of a war correspondent," said Mr. Franck Z. Maguire, of London, vice-president of the American De Forest Wireless Telegraph Company. "Newspapers have been spending vast sums of money to procure news in the far east, and it remained for the most conservative of all of them, the London *Times*, to enlist the services of wireless telegraphy. Two of the principal events of the war have been delivered ahead of other methods by wireless telegraphy. Messages from one to two columns in length are sent.

"Recently the *New York Times*, which also has our service, had three despatches, in all over a column in length. I am informed that some 300 papers are being supplied. It must be pretty good work, for I notice that a foreign company is advertising that it has exclusive contracts with the *Times*, notwithstanding the fact that we hold the documents and are given proper credit, day by day, in most of the papers.

"During the bombardment of Port Arthur the reports were sent by our system from among the Japanese fleet while in action. In other words, as the bombardment was going on the news was being sent across the sea to Wei-hai-wei, over a hundred miles. Every detail was given and the report has been considered by newspaper men as a 'classic' in the annals of war reporting. The second event, which was the attempt to 'bottle up' the Russian fleet, was graphically described, and a column and a half were sent from Korea bay over a hundred miles at sea. Now here is a revolution produced, and when people are thoroughly awakened to what has really been done, Dr. De Forest will receive the great credit he deserves. It is also to be noted that in the bombardment the Japanese utilized wireless telegraphy for the directing of the fire. The heavy guns were over seven miles from Port Arthur. There were, however, placed on either side, several miles nearer the forts, vessels equipped with wireless telegraphy which directed the course of the firing. For instance, if the battleships which were firing at an exceedingly long range were landing shells too far to the right, they would be told by wireless to change the course. This is a matter of history, and can easily be verified. The Japanese have equipped many of their vessels,

and one of the government's representatives did us the honor of spending a week at our laboratory several months ago.

"The evasion of the censor has been accomplished in the instance, in this way. The station at Wei-hai-wei is in China on British territory. The despatch boat Haimun is really traveling in Chinese waters. The correspondent may cross to Chemulpo (about 200 miles), go up to Seoul, which is thirty miles inland, get the news and not send a word until he is outside the three-mile limit beyond Chemulpo. When you come to consider that there were forty-five correspondents in Tokio waiting to get to the 'front' and only a few were actually permitted to do so, perhaps you may realize what I mean when I say a revolution in war reporting has been produced by our system.

"General Greeley, the chief Signal officer, told me recently in Washington that two government stations utilizing our apparatus (forts Schuyler and Wright) had been working daily since installed, six weeks, without interruption, save one day when one of the station wires blew down in a sleet-storm. That's as good as land service and we can practically work at thirty words a minute. We are also getting Buffalo from Cleveland daily, which is a distance of 182 miles, partly overland. I regard our overland developments as important as those at sea. When you can for a few hundred dollars connect towns fifty or one hundred miles apart it means business, and this is what we are prepared to do."

"Are you having any difficulty with interference?"

"No, we are not. The service in the far east demonstrates that point very satisfactory. The Japanese boats, as I have said, are equipped with wireless. They do not interfere with us. When we were having our government test in England there was another station utilizing a foreign system at work all the while. The English experts were much interested to listen and distinguished the different sounds. The reason why we do not suffer as do some foreign systems I know of is because we do not use a tape recorder, but read from sound in the telephone. We therefore can readily distinguish our signals from outside vibrations that may come along. We have done good work, but have only commenced to show the possibilities of this invention."

Washington, D. C., Telephone Rates.

The Chesapeake & Potomac Telephone Company has secured a substantial victory with regard to the cost of telephones for business houses in Washington, D. C. A provision in the District of Columbia Appropriation Bill, fixing the rates for telephone service, repeals a former act, in so far as business houses are concerned, practically allowing the local company to name its own terms. It limits to $60 a year the amount to be paid by the government for an individual metallic circuit, and to $40 for each telephone when two or more are on the same circuit.

The previous law on the subject, enacted in 1898, made graded limitations for different services considerably lower than the new rates, but provided no penalty for violations. The local company maintained its original charge, and, as a result, nearly 100 injunctions were sued out by subscribers to prevent the removal of telephones after the prescribed rates had been tendered. The cases were bitterly fought, and were twice taken to the Supreme Court, which finally decided that the limitations did not apply to metallic circuits. As the great majority of the business lines were of that character, it was a victory for the company. Now Congress repeals the law entirely and raises the limit of cost for telephones in residences to $60 a year, and permits the company to fix its rates for business houses. President U. N. Bethell and his associates are very much pleased at the turn which the affair has taken, as it has been a litigation of the most vexatious character.

Canadian Electrical Association.

At a meeting of the executive committee of the Canadian Electrical Association held on April 21, it was decided to have the annual convention meet in the city of Hamilton on Wednesday, Thursday and Friday, June 15, 16 and 17. Committees were appointed to make the necessary arrangements. A series of interesting papers has been arranged for.

Steam Turbine Propulsion for Marine Purposes.

A paper discussing the use of the steam turbine for marine purposes was read by Professor A. Rateau before the British Institution of Naval Architects on March 25. There are at present two ships fitted with the Rateau turbine—a French torpedo boat and a first-class British torpedo boat built by Messrs. Yarrow & Company. The advantages of the turbine for such work are: absence of vibration, great reduction in weight, ease of handling, absence of wear and tear, etc. The principal difficulties in applying turbines to the propulsion of ships lie in the design and arrangement of propellers for high speed of rotation, inefficiency of turbines at low speeds, and in reversing and manœuvering. When the turbines are not restricted to any particular speed of rotation, a very high efficiency can be obtained—certainly higher than that of the best reciprocating engine. Unfortunately, the best speed for turbines is much too high for screw propellers. In high-speed vessels, a working arrangement can be arrived at, but is not easy to do. The gearing of the rings has to be higher than with the turbine for other purposes, and the turbine itself must be divided into several sections in series; and, further, it is necessary to devise some arrangement for the propellers by grouping them either singly, in pairs or in threes on several shafts, so as to increase their surfaces, that the extreme outside diameter shall be greater than the pitch, all of which tend to reduce the total efficiency of engines and propellers.

While the turbine is theoretically superior to the reciprocating engine, it is not by any means certain that the joint efficiency of both engine and propeller is better or even as good. Moreover, practical difficulties increase as the speed diminishes. There is a low limit for speeds, below which the use of turbines can not be recommended, and the author believes that this limit is in the neighborhood of twenty knots. If the steam turbine is capable of giving good results at the maximum power, it can not be gainsaid that the results are certainly unsatisfactory at reduced speeds, not so much on account of the reduction of power as on account of the reduction in the speed of rotation, which involves a lowering of what is termed the hydraulic efficiency of the turbine. This drawback does not signify in the case of merchant vessels, which keep at their maximum speed. On the other hand, it becomes a serious one on warships that are rarely worked at full power. A partial remedy, as used by Mr. Parsons, may be effected by adding a supplementary turbine for cruising purposes; but this does not improve the hydraulic efficiency of the turbine, and the steam consumption remains high. The author considers that under no circumstances can turbines alone be economically worked at low speeds, and that the only satisfactory solution is the employment of a reciprocating engine of more or less power in conjunction with turbines. With this combination, economical results can be obtained at all speeds.

Various inventors have attempted to reverse the steam turbine by means of special blades, enabling the same range to be used for both directions of motion; but these attempts do not appear likely to come to anything, as one can only obtain reversibility by a considerable sacrifice of

efficiency in forward motion. It is therefore necessary to supplement the turbine by special engines for going astern. Professor Rateau accomplishes this by adding a small turbine, placed inside the main turbine on the low-pressure side, without taking up any additional space. When they revolve freely, the stern rings offer no appreciable resistance while the main turbine is at work. With a single live ring, and for the same expenditure of steam, this turbine will give a stern speed of about forty per cent of the speed ahead. Adding a second ring increases it to fifty per cent, and the addition of other rings adds but little. For quickly stopping a vessel turbines are inconvenient. In Professor Rateau's opinion it is important for warships to be able to manœuvre with ease; and this requirement will necessarily lead to the adoption of the combined system of turbines and reciprocating engines.

If turbines and reciprocating engines are used, the best results are obtained by connecting each to an independent shaft, since the speeds of the two engines are so different. The power of the reciprocating engine should not be less than one-sixth of the total, and it can well be increased to one-third or even one-half of the maximum horse-power. But even with this arrangement, the weight of the combined engines is less than that of the present system, though somewhat more space is required. The combined system is easier to work and to maintain, and saves in personnel, also reducing the vibration of the ship and increasing the efficiency. This arrangement also makes it possible to use turbines advantageously at lower speeds. The combined system is suitable for speeds of fifteen knots or perhaps even less.

LETTERS TO THE EDITOR.

A Plea on Behalf of the Consulting Engineer.

To the Editor of the Electrical Review:

I read with much interest the editorial in your issue of April 9 on "The Remuneration of the Engineer." It seems to cover the ground fairly well, but you have omitted one of the most important causes that contributes to keeping the public from appreciating and therefore being willing to pay a proper price for engineering services. This is the custom of buyers generally having their engineering done by the manufacturing companies. The plants so engineered will always operate, but they often cost more than if engineered by an agent of the purchaser. "Where a man's money is there will his heart be also," and from a business standpoint a representative of the buyer is—well, more interested in keeping the cost down. The advice from manufacturers "have plenty of reserve capacity, don't skimp" is as old as the manufacturer of machinery, and accounts for so much apparatus working on one-quarter load at a corresponding efficiency, that is found all over these United States.

If manufacturers' salesmen did not sell all the machinery they could and at the best possible price they would not be human, nor worth their salt; so this is not an accusation of bad faith on the part of the manufacturers—merely a statement of business facts which should indicate to a prospective purchaser the advisability of having his own representative supervise the spending of his money and pass on the character of the equipment supplied.

Consulting Engineer.

New York, April 21.

Radioactive Phenomena.

To the Editor of the Electrical Review:

We read from time to time articles regarding radium and the theory of the emanations therefrom being the cause of the radioactivity. We have noted the statements that radium was forever throwing off particles without losing anything, and that it is the impact of these particles which causes the burning effect, etc.

We can not entertain any theory whereby a material is giving something and losing nothing.

We know of nothing that will stop the magnetic attraction of a magnet. The interposing of any substance known between a magnet and the iron armature has no effect upon the magnetic waves—the attractive force of the magnet.

We have proof that magnetic waves are radiating from all directions to the centre of the earth.

We know that a steel bar held at an angle with the polarity of the earth and struck a blow becomes a magnet. And why? The magnetic waves pass from the outside through all bodies of any character without resistance alike, the steel and iron bar included, but, for some reason unknown to the writer, steel has the property necessary to retain the magnetic waves under certain conditions and thereby becomes a magnet, the natural magnetic waves no longer passing through without resistance, but setting up a swirl in the steel which is indicated in the experiment if iron filings on a piece of glass under which a magnet is placed.

You will ask what connection the magnetic waves and magnets have with radium.

Can you conceive of a more natural theory than that radium is a substance which offers resistance to the magnetic waves? These waves striking the substance and meeting resistance cause it to heat and it retains its heat, not on account of the countless particles breaking and flying off, but by the continual impact of the magnetic waves which are not free to pass.

Twenty years ago we saw impressions of an ordinary wrought-iron washer made on photo plates, securely wrapped in black paper, by inserting the plate between the fields of powerful magnets.

Is it not possible that photos made by radium is the result of the free passage of the magnetic waves outside the influence of the radium and the retarded waves due to the radium?

Is it not possible that the florescence of radium is a circumstance and not the fact that gives it the properties attributed to it, and that the retardation of the magnetic waves is the real factor?

Is the theory worthy of discussion?

H. F. Lowther.

Scranton, Pa., April 21.

The United Press to be Revived.

Mr. Walter P. Phillips, inventor of the Phillips system of telegraphy, announces that the United Press is to be revived on May 2 for the purpose of doing a general advertising business with especial reference to handling reading matter-advertising by telegraph. The extent of the business, it is believed, will soon warrant the leasing of wires on which the Phillips system of telegraphy will be employed. This system will be shown, with other electrical devices of Mr. Phillips, in the Electricity Building, St. Louis Exposition, and he extends a cordial invitation for all interested to call and see it. The exhibit will be situated in close proximity to the Western Union and Postal Telegraph-Cable companies, and will be in charge of Mr. William Ireland Starr.

Mr. Phillips was general manager of the old United Press from 1882 until 1897. The new United Press will have for its general manager Mr. P. V. DeGraw, formerly general southern manager of the United Press at Washington. Its secretary will be Mr. William C. Davis, for many years the general counsel of the United Press, and its offices are at 120 Broadway, New York city.

The American Institute of Electrical Engineers.

Papers on Alternator Design and Regulation Read at the 186th Meeting.

THE 186th meeting of the American Institute of Electrical Engineers was held at Carnegie Hall, New York city, Friday evening, April 22. Vice-president Rice was in the chair.

The first paper of the evening was entitled "The Mechanical Construction of Revolving-Field Alternators," by Mr. David B. Rushmore, of Pittsfield, Mass. Mr. Rushmore, by means of lantern slides, described the development of alternator design, showing how each type of machine had been modified in the light of experience gained from previous designs. Parts of the machines were taken up in detail, considerations affecting their proportions were discussed, and the undesirable as well as the good features of the machines as a whole pointed out. Other special considerations, such as the maximum weight of parts for shipping, high-speed construction, etc., were also dwelt upon in this interesting paper.

The second paper of the evening was entitled "A Contribution to the Theory of the Regulation of Alternators." This is by Messrs. H. M. Hobart and F. Punga, of London, England. In the absence of the authors, the paper was admirably abstracted by Mr. Gano S. Dunn, of Ampere, N. J. This paper, which appears on another page of this issue, describes a new method of predetermining the regulation of alternators, which the authors believe gives excellent results.

The discussion was opened by Professor Comfort A. Adams, of Cambridge, Mass., who said that a generalization might be made covering all electrical machines, though, in certain cases, the terms used might seem somewhat loose. There are always two electrical circuits, which may be called the primary and secondary, and three fluxes to be considered: the main flux and the leakage fluxes of the primary and the secondary windings. This raised the question of exactly what might be meant by "leakage." Professor Adams thought that the authors had stopped a little short of what should be called "leakage" in their treatment. They have averaged values, but the fact that the averaging was necessary shows that a variation takes place, which variation must set up an electromotive force. This effect will naturally be greater for single-phase machines than for polyphase. The method proposed, however, was more detailed than general in such discussions; but, in any case, compromises must be made, approximations must be assumed, and the effect of leakage is apt to be more important than the paper would lead one to believe.

Professor Adams then discussed the method of predetermining regulation which he has been using, and which he believes gives results as accurate as this new method, while it is simpler. This method is based upon the application of the general transformer diagram to the alternator.

Mr. B. A. Behrend, of Cincinnati, Ohio, before taking up the discussion of the proposed method, cautioned against attaching too much importance to such methods of analysis. He said that a paper on alternator regulation always reminded him of Hume's remarks about philosophy: "A subject of very great interest, but of very little importance." Mr. Behrend then made the point, that it is impossible to test large alternators under load at unity power-factor, although this test is often called for in specifications. It had been pointed out thirty years ago that the water rheostat gives a capacity load which strengthens the magnetic field, though this effect seems to have been forgotten in recent years. Another point which should be borne in mind is the difficulty of measuring power-factors accurately. The only test which can be relied upon is a load test at zero power-factor, for obtaining which there are a number of ways. But regulation under these conditions gives no indication of what it will be under at power-factors. Further, it is necessary to know the shape of the saturation curve of the machine. In his own opinion, if the designer, from his knowledge of the conditions to be met, puts out a machine which does meet these conditions, that machine is all right.

Mr. Behrend then commented upon the complexities of this problem, which are such as to make it almost impossible of exact solution, and he thought that, under such conditions, it is better for us to acknowledge our ignorance, than to deceive ourselves with false assumptions.

Returning to the paper, Mr. Behrend pointed out that Messrs. Hobart and Punga have considered armature leakage only, and have not taken into account the field leakage, which, in fact, is as important as the other.

Mr. Calvin W. Rice read a communication from Mr. W. L. Waters, of Milwaukee, Wis., which considered the paper at some length. In this it was pointed out that the new method was not free from assumptions, and there seems to be a confusion of the inductive leakages, due to the rotation of the field and to the armature currents. He described the method which he has been using, in which the inductance is computed for two positions of the armature coil with respect to the pole-face. This method, he believes, gives quite satisfactory results, but no elementary theory can cover a case with so many complexities, and any designer must be forced to use empirical methods.

Mr. Waters, referring to the paper read by Mr. Behrend during the past year, said that he considered it the best exposition of this complicated problem.

Mr. Behrend rose to give credit for the method which he had been using to Professor Alexander Potier, the eminent French mathematician. Four years ago Mr. Behrend had given M. Potier a great deal of data which he had taken himself, and from this M. Potier had worked out a solution which Mr. Behrend had used. M. Potier is at present seriously ill, and Mr. Behrend took very great pleasure in giving him full credit for this solution.

Replying to the discussion, Mr. Dunn said that Messrs. Hobart and Punga do not neglect the field leakage in computing the inductance, but this is allowed for in other ways, and that the authors from their paper show that they appreciate the necessity of recognizing the shape of the saturation curve. Mr. Dunn emphasized his belief that machine design is an art, and not a science, a fact which should be more fully recognized.

Replying to a question from Mr. Dunn, Mr. Rushmore said that an elastic arrangement is used in high-speed machines in certain of the types which he had pointed out, which allows the strains due to centrifugal forces to come upon the annular field ring, and not upon the spokes. Mr. Rushmore, in discussing the paper on alternating design, said that he had found it possible to estimate regulation pretty closely by a method similar to Mr. Behrend's.

Mr. H. G. Stott, when asked to give some figures of regulation which practice had shown satisfactory, said that, due to the lateness of the hour, he would communicate this information in writing.

The meeting then adjourned.

A CONTRIBUTION TO THE THEORY OF THE REGULATION OF ALTERNATORS.[1]

BY H. M. HOBART AND F. PUNGA.

The interesting paper recently contributed by Behrend to the proceedings of the Institute has incited the writers to the preparation of the present paper, which sets forth their own views regarding the regulation of alternating-current generators.

It is unnecessary to refer to the theories of others, since these have so recently been discussed by Behrend[2], who has shown by means of practical examples that none of these theories gives correct results for different types of machines.

The theory which the writers describe in this paper has been tested on but a limited number of machines, but has in these cases given such excellent results as amply to justify its publication, in the hope that this will lead to its being subjected to further tests in impartial quarters. Moreover the writers entertain the hope that the theory itself will, independently of practical examples, prove convincing in virtue of its inherent simplicity and clearness, and its freedom from hypothetical assumptions. Nevertheless its reliability must of course be demonstrated by testing it by a large number of practical examples of various types of machines. It is our intention to bring together such practical examples in a treatise on the design of alternating-current generators, in which this theory will be employed in the sections relating to voltage regulation.

The change in the voltage of a constantly excited alternating-current generator, when its load is varied in nature or amount, is chiefly occasioned by the magnetic flux set up by the current in the armature winding and linked with the turns constituting the winding. These lines may be classified according as they flow in one or the other of three paths, as shown in Fig. 1.

First Path—The lines never emerge from the armature. They consist of those which cross the armature slot from side to side, and those which are linked with the end connections.

Second Path—The lines emerge from the armature and cross the air-gap toward one end of the pole-shoe, and after passing along the pole-shoe return across the air-gap to the armature from the other end of the pole-shoe.

Third Path—The lines, after emerging from the armature, traverse successively the air-gap, pole-shoe, magnet-core, yoke, adjacent magnet-core, and pole-shoe, and after again traversing the air-gap, reenter the armature.

The lines following the first path are purely self-inductive, and all methods of treatment in which they are correctly handled are applicable also to our theory.

Hence for sine curves of electromotive force and current, one applies the recognized vector diagram of Fig. 2 in which

OA = the electromotive force generated in the armature winding by the lines crossing the air-gap = internal electromotive force.

OC = current flowing in the windings.

OD = BE = the reactance voltage generated in the armature winding by the current OC flowing in it.

AB = voltage-drop due to ohmic resistance.

OE = terminal voltage.

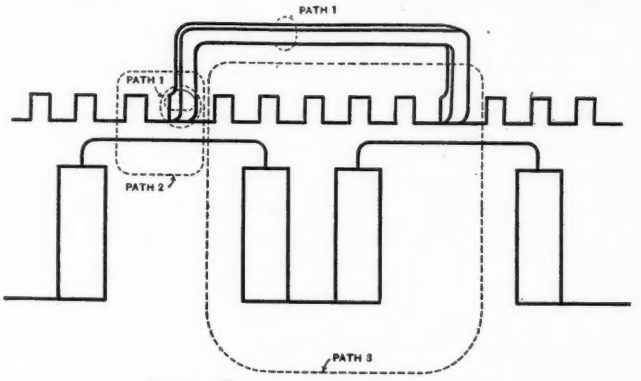


FIG. 1.—REGULATION OF ALTERNATORS.

α = angle AOE between internal electromotive force OA and terminal electromotive force OE.

ϕ = angle EOC between terminal electromotive force OE and current OC.

The magnetic flux belonging to the second and third paths can be best considered if we, for the moment, neglect the magnetic reluctance of the iron (armature laminations, magnet core, and yoke).

In Fig. 3 is shown a magnet-pole with a single armature conductor at the centre of the polar pitch. When the conductor carries no current, the magnetic flux across the air-gap will be generated solely by the field magnet ampere-turns, and will be uniformly distributed over the pole-arc. It may be represented by the rectangular area, 1, 2, 3, 4, the spreading at the pole-tips being neglected.

Let us now consider the case when a current of i amperes flows through the conductor; the ampere-turns per field-spool will be denoted by A; the total armature strength per pole, denoted by $i/2$, is, according to the conditions of load, to be added or subtracted from the field ampere-turns A.

In the case shown in Fig. 3, the left half of the pole-arc is subject to the influence of $(A - i/2)$ ampere-turns, the right half, to $(A + i/2)$ ampere-turns. The density of the magnetic flux is proportional to these ampere-turns, since the magnetic reluctance of the iron is, for the time, neglected. The distribution of the magnetic flux may now be diagrammatically represented by the area 1, 5, 6, 7, 8, 4, shown in Fig. 3. What now, is the effect of this distribution?

In the case under consideration where the conductor lies at the middle of the pole-pitch, the total number of lines of force entering the armature is unaffected by the armature current; *i. e.*, the area 1, 5, 6, 7, 8, 4 is equal to the area 1, 2, 3, 4, and what has been lost on the one side of the conductor has been exactly made up by the gain on the other side.

2. The internal electromotive force generated by this flux is not only not decreased, as might hastily have been concluded, but is even slightly increased, as is evident when we consider the electromotive-force formula

$$E = k\,TNM \times 10^{-8}$$

The periodicity N, the total flux M and the turns per phase T have not been altered, but k has become slightly greater, for the alteration in the form of the magnetic field has precisely the same effect on k as would occur in virtue of a decrease in the ratio of

pole-arc : pitch[1]

3. Another effect of the current in the armature conductor in Fig. 3 relates to the shifting of the central line of the total magnet flux.[2] It may be seen from Fig. 3 that the centre of the figure representing the magnetic flux is no longer the same

[1] A paper presented at the 186th meeting of the American Institute of Electrical Engineers, New York, April 22, 1904.

[2] Transactions American Institute Electrical Engineers, vol. xx., p. 739.

[1] The dependence of k upon the ratio of pole-arc to pitch was probably first pointed out by Kapp. It is very exhaustively treated on pages 82 to 85 of "Electric Generators."

[2] First pointed out by Blondel (*L'Industrie Electrique*, 1899).

as when the armature-conductor carried no current. The line g then represented the centre of the flux, the magnetomotive force of the current in the armature-conductor has shifted the centre of the resultant flux distribution to the line h. These considerations are capable of being readily extended to the case of the flux distribution where the conductor occupies any other than the middle position opposite the pole-arc. The flux distribution in such a case is illustrated diagrammatically in Fig. 4, and the principal difference between this flux distribution and that of the previous case where the conductor occupied the middle position is seen to consist in a decrease in the total number of magnetic lines due to the current in the conductor, whereas in the former case the total number of magnetic lines remained unchanged.

Of the three considerations enumerated above, we shall confine our attention to the first and third; since the influence of the change in k is comparatively slight, and since also it is, in actual practice,

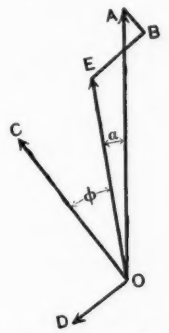


Fig. 2.—Regulation of Alternators.

largely or altogether offset by the increasing magnetic reluctance of the teeth, consequent upon the increased local saturation brought about by distortion. Hence it is not only simpler, but actually more correct to disregard both of these opposing influences.

In order to study more carefully the influence of the armature magnetomotive force upon the magnitude and distribution of the magnetic flux, the diagram of flux distribution in Fig. 4 has been reproduced in Fig. 5. Since our purpose is to compare the flux distribution in the same machine under two different conditions we do not need to employ absolute values, but may represent by A the ordinate of the plane rectangular figure representing the flux distribution when there is no current in the armature-conductor, setting its abscissa, the pole-breadth, equal to b. The abscissa representing the position of the conductor measured from the right-hand end of the pole-face, may be designated by x. From the figure we obtain at once:

Number of magnetic lines entering armature when there is no current in the conductor = A b.

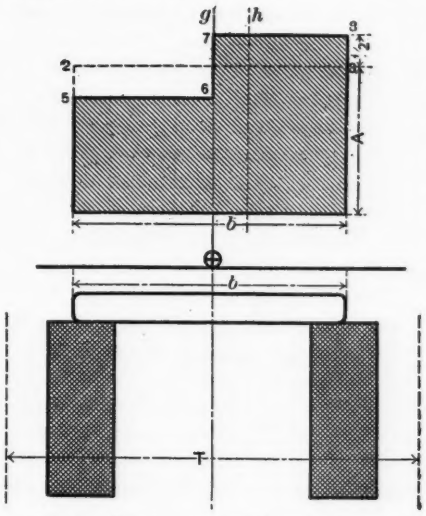


Fig. 3.—Regulation of Alternators.

Number of magnetic lines entering armature when the conductor carries the current $i = (\mathrm{A}\ b - i/2)\ b + x\ i$.

The calculation of the amount of shifting of the centre of the total magnetic flux consists in ascertaining the position of the ordinate passing through the centre of gravity of the surface. When no current flows it is obvious that the magnetic and geometric centres are identical. But this identity must also occur in the extreme case represented in Fig. 6, where the armature magnetomotive force $i/2$ equals that of the field-magnet spool. The magnetic and geometric centres are also identical in all intermediate cases. Returning to the diagram of

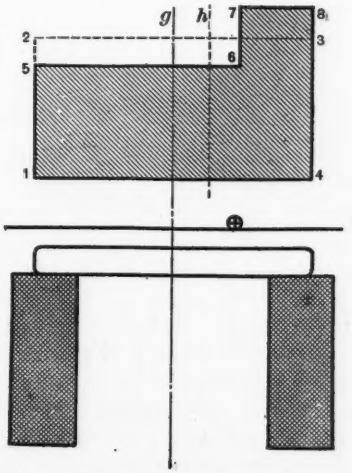


Fig. 4 – Regulation of Alternators.

Fig. 5, let the distance of the magnetic centre from the mid-pole position be designated by y; then;

$$y = \tfrac{1}{2}\,\frac{x\,(b-x)\,i}{\mathrm{A}\,b - (b\,i/2) + x\,i}\ ^{1}$$

Conductors lying between adjacent pole-tips are without influence upon the factors $x\ (b - x)\ i$ and $x\ i$, which are proportional to the distortion. They exert a direct demagnetizing influence and thus affect the total flux. Hence, in obtaining the values of the factors $x\ (b - x)\ x\ i$ and $x\ i$, only those conductors are to be considered which lie directly opposite the pole-face. But in obtaining the value of $(b\ i/2)$, the total number of conductors per pole should be considered.

The calculation of the pressure-drop in a machine would by this method be far too laborious. But fortunately the method may be greatly simplified for the case of sine curves of electromotive force and current.[2]

SINE-WAVE ALTERNATORS.

In the many cases where we may for practical purposes assume a sine-wave form of electromotive force and current, the decrease in total magnetic flux as the resu'lt of the armature interference may be attributed to and derived from the de-

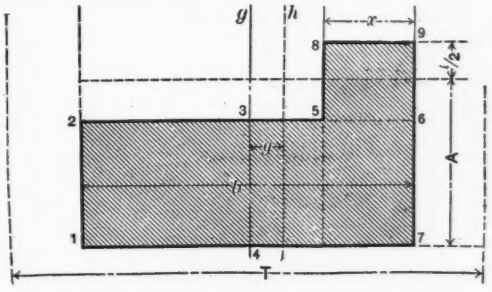


Fig. 5.—Regulation of Alternators.

magnetizing ampere-turns, and the shifting of the flux centre, to the distorting ampere-turns.

The magnitudes of these values, as

[1] This formula is derived as follows (Fig. 5):

Total surface $\times\ y$ = surface (1, 2, 3, 4) $\times\ (b/2)$ + surface (3, 6, 7, 4) $\times\ (+\,b/2)$ + surface (5, 8, 9, 6) $\times\ (b/2 - x/2)$

Since surface (1, 2, 3, 4) = surface (3, 6, 7, 4), we have

$$y = \frac{\text{Surface (5, 8, 9, 6),}}{\text{Total surface}}\left(\frac{b}{2} = \frac{x}{2}\right)$$

The ratio $\dfrac{\text{Surface (5, 8, 9, 6),}}{\text{Total surface}}$ is, however,

equal to

$$\frac{x\,i}{\mathrm{A}\,b - (b\,i/2) + x\,i}$$

hence, in general

$$y = \tfrac{1}{2}\,\frac{x\,(b-x)\,i}{\mathrm{A}\,b - (b\,i/2) + x\,i}$$

[2] Since it is sometimes required to calculate the pressure-drop for machines where sine-wave assumptions are not permissible, this general analytical method is followed out to its conclusion in appendix I, and therein are also set forth the uninteresting but essential steps leading up to the derivation of table I, which result alone among the matter contained in appendix I is essential to the application of the theory to those alternators in which a sine-wave assumption is justifiable. For practical purposes this is generally found to be the case, hence the contents of appendix I possess interest only for those who wish to follow through the steps leading up to the practical results. Those who only wish to satisfy themselves of the soundness of the method can do so by applying it to machines with which they are familiar, in the way illustrated in this paper.

dependent upon the ratio pole arc: pitch are given in table I[1] for a single-phase alternator with one slot per pole, when loaded to an armature strength of $n\ i$ effective armature ampere-turns per pole.

TABLE I.

DEMAGNETIZING AND DISTORTING AMPERE-TURNS FOR THE CASE OF A UNI-SLOT, SINGLE-PHASE ALTERNATOR.

	$b/\tau = 0.5$	$b/\tau = 0.6$	$b/\tau = 0.6$
Demagnetizing ampere-turns	$0.82\,(n\,i)\sin\phi'$	$0.78\,(n\,i)\sin\phi'$	$0.75\,(n\,i)\sin\phi'$
Distorting ampere-turns ...	$0.11(n\,i)\cos\phi'$	$0.15(n\,i)\cos\phi'$	$0.20(n\,i)\cos\phi'$

In table I: ϕ' is the angle between pole-centre and that position of the armature-conductor where it carries maximum current and, consequently, exerts its maximum magnetomotive force, the polar-pitch being taken as 180 degrees. While the demagnetizing ampere-turns are to be directly deducted from the field-spool ampere-turns in determining the resultant magnetomotive force, we may from the distorting ampere-turns determine the angular distance β from the magnetic centre by means of the equation degrees shift of the magnetic centre β

$$= \frac{\text{Distorting ampere-turns per pole}}{\text{Air-gap ampere-turns per pole}} \times 90^{\circ}\ ^{2}$$

The influence of the pole-arc on the demagnetizing and distorting ampere-turns

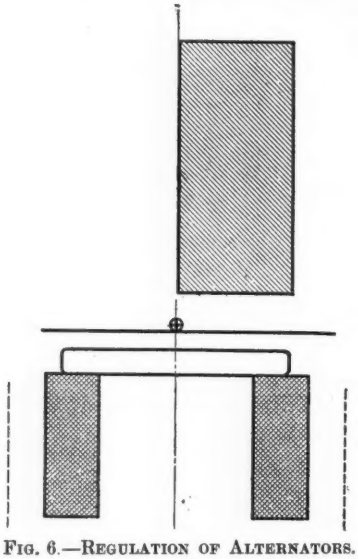


FIG. 6.—REGULATION OF ALTERNATORS.

is of considerable interest. With increasing ratios of

Pole-arc : pitch

the demagnetizing ampere-turns very slowly decrease. But the distorting ampere-turns, on the other hand, increase, and very rapidly; in fact their rate of increase is as the square of the increase in the ratio of the pole-arc to pitch. This circumstance may be of importance in the

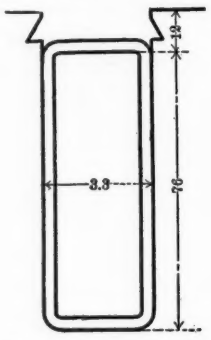


FIG. 7. REGULATION OF ALTERNATORS.

choice of the pole-arc. When, for instance, a certain closeness of regulation for $\cos\phi = 1$ is required, it may be distinctly advantageous to design the machine with a relatively small pole-arc and thus decrease the distortion. But when it is required to obtain a given degree of regulation for $\cos\phi = 0$, one will obtain the best results by means of a larger pole-arc.

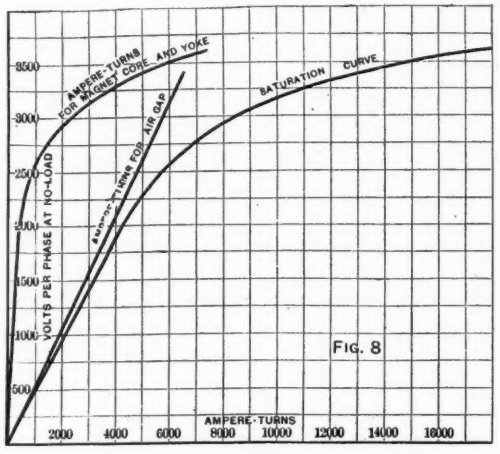


FIG. 8.—REGULATION OF ALTERNATORS.

SINGLE-PHASE DISTRIBUTED WINDINGS.

It is relatively simple to extend the calculations to other types of winding. Thus, when the single-phase alternator has many slots per pole, or a uniformly distributed winding, both the demagnetizing and distorting influence will be somewhat less; since for the different sections of the winding the maximum magnetomotive force occurs when these sections occupy different positions with respect to the pole-centre. When for example one side of a winding covers one-third of the pole-pitch, it will be necessary to multiply the values given in table I for the armature interference by 0.95. This quantity is designated the "breadth-factor" and has, for various types of winding, the values set forth in table II.

TABLE II.

Percentage of Polar Pitch Covered by One Side of the Armature Winding.	"Breadth-Factor."
20	0.99
40	0.94
60	0.86
80	0.76
100	0.64

APPLICATION TO POLYPHASE GENERATORS.

Nothing new is encountered in applying these principles to the case of polyphase generators. One must merely first calculate the armature interference for one phase and then multiply the values thus obtained by the number of phases. The ampere-turns are thus combined algebraically and not geometrically.[1] The correctness of this proposition is at once recognized when it is considered that all the phases are identical; for we have the same number of turns, and the same current per turn, and the current reaches its maximum value for all phases when at the same distance from the mid-pole face position.

In order to make the final forms of the expressions for the demagnetizing and distorting ampere-turns as simple as possible, we shall denote the effective ampere-turns per armature pole by $n\ i$, and combine the results of tables I and II in table III.

TABLE III.

GENERAL CASE FOR DEMAGNETIZING AND DISTORTING AMPERE-TURNS.

	Armature Ampere-Turns (Effective) per Pole.		
	$b/\tau = 0.5$	$b/\tau = 0.6$	$b/\tau = 0.7$
Demagnetizing ampere-turns	$0.82\,B\,n\,i\sin\phi'$	$0.78\,B\,n\,i\sin\phi'$	$0.75\,B\,n\,i\sin\phi'$
Distorting ampere-turns ...	$0.11\,B\,n\,i\cos\phi'$	$0.15\,B\,n\,i\cos\phi'$	$0.20\,B\,n\,i\cos\phi'$

The application of these methods to the results obtained experimentally on a typical alternator will suffice to show the method of applying this theory of the regulation of alternators. The machine investigated was one of the three-phase generators installed at the Shepherd's Bush power-house of the Central London Railway. The rated output is 850 kilowatts at unity power-factor. The machine has

[1] The derivation of table I is given in appendix I, as indicated in the preceding foot-note.

[2] It might be more exact in some cases to make some allowance for the magnetomotive force required by the teeth.

[1] An experimental proof for this assertion may be found in the table page 16a, which shows the agreement between observed and calculated values for seven single-phase generators and for eleven three-phase generators.

thirty-two poles, and a speed of ninety-four revolutions per minute, the periodicity being twenty-five cycles per second. The pressure between terminals is 5,000 volts, corresponding to 2,880 volts per phase, and for each of the Y-connected armature windings.

The leading dimensions are set forth in the following specification:

Armature diameter	3,666	mm.
Gross width of armature core between flanges	368	"
Number of ventilating ducts	5	
Width of each ventilating duct	13	mm.
Effective width of armature core	274	"
Number of slots	192	"
Number of slots per pole per phase	2	
Depth of slot	92	mm.
Width of slot	33.4	"

FIELD.

Length of pole-arc	228	mm.
Polar pitch	360	"
Ratio of pole-arc to pitch	63.3%	
Radial length of magnet-cores	840	mm.
Diameter of bore of field	3,644	"
Radial depth of air-gap	8	"
Dimensions of cross-section of magnet-core	16.5 × 37	sq. cm.

WINDING.

Number of armature-conductors	2,688	
Number per slot	14	
Number of turns per pole and per phase	14	
Effective armature ampere-turns per pole per phase at full-load current of ninety-eight amperes	1,380	
Each armature-conductor consists of twenty-six strands of No. 17 B. W. gauge.		
Mean length of one armature turn	161	cm.
Embedded length	55	"
Free length	106	"

We shall first calculate the short-circuit current, since this is generally experimentally observed, and constitutes a good test of the theory. The estimation of the short-circuit current requires a determination of the inductance of the winding. With straight-sided slots a good approximation to the inductance of the embedded part may be obtained by elementary magnetomotive-force calculation thus:

Let D = depth of slot in centimetres.
d = depth above top of winding in centimetres.
W = width of slot in centimetres.

Number of lines per ampere-turn per centimetre of embedded length, may, for the case of the inductance of the winding in a single slot, be taken as approximately equal to

$$\frac{4\pi}{10}\,\frac{\frac{1}{2}(D-d)+d}{W} = 0.63\,\frac{D+d}{W}$$

In the case in question (see Fig. 7)

$$D = 9.2 \qquad d = 1.2 \qquad W = 3.3$$

$$\text{Number of lines} = 0.63 \times \frac{9.2+1.2}{3.3}$$

$$= 1.99 \text{ per centimetre}$$

of embedded length and ampere-turn. Now, there are two slots per pole per phase, hence the length of the magnetic path through the air is doubled and the number of lines per ampere-turn per centimetre of embedded length becomes $1.99/ = 1$.

(To be concluded.)

An Interesting Meeting of the Magnetic Club.

The members and guests of the Magnetic Club banqueted at the Hotel Spalding, New York city, Thursday evening, April 21. The occasion was "in honor of the Bell telephone," as the programme stated, and among those at the guests' table were Mr. Frederick P. Fish and Mr. E. J. Hall, president and vice-president, respectively, of the American Telephone and Telegraph Company; Messrs. Charles F. Cutler and U. N. Bethell, president and vice-president, respectively, of the New York Telephone Company; Mr. W. D. Sargent, Mr. J. C. Reilly, Mr. F. A. Pickernell, Mr. Charles W. Wilson, Mr. T. D. Lockwood, Mr. Charles E. Scribner, and Mr. B. Gherardi, Jr.

The banquet hall was well filled, and the occasion was ably presided over by President F. W. Jones. Interesting and eloquent addresses were delivered by Mr. Fish, Mr. Bethell, Mr. G. G. Ward, Mr. Melville E. Stone, Mr. A. B. Chandler, Mr. C. P. Bruch and others, the invention of the telephone and its vast influences over life forming the chief topics. The occasion was enlivened by a number of topical songs suitable to such a gathering of prominent telephone and telegraph officials. Others in attendance, besides those named above, were Colonel R. C. Clowry, Clarence H. Mackay, William H. Baker, George H. Fearons, Alexander Cameron, W. L. Candee, F. S. Gaston, George T. Manson, Colonel E. De Forest, W. H. Hodgins, H. D. Cheever, J. R. Van Wormer, B. Brooks, E. C. Platt, J. C. Barclay, W. H. Hurst, T. Brennan, J. J. Ghegan, T. A. Brooks, James Kempster, H. L. Shippy, Walter P. Phillips, F. H. Wilkins, H. B. Thayer, E. M. Mulford, C. H. Bristol, L. B. Foley, F. J. Scherer, J. M. Creamer, J. Merrihew, C. R. Bangs, M. Egleston, W. Hopkins, J. L. Hamar, G. F. Porter, S. S. Dickenson, E. W. Parker, H. C. Entrup, William Maver, Jr., A. P. Eckert, J. B. Taltavall, John Burry, T. L. Cuyler, Jr., W. B. Van Size, B. M. Downs, G. H. Usher, A. L. Salt, H. F. Thurber, G. C. Allen, Dr. H. S. Snow and H. G. McCully.

Both Professor A. Graham Bell, the inventor of the telephone, and Mr. E. M. Barton, president of the Western Electric Company, Chicago, who is one of the pioneers in the development of the telephone and still one of its ablest advocates, were among the invited guests, but were unable to be present.

The Magnetic Club was organized for the purpose of bringing together in a pleasant, social way the officers and toilers in the ranks of telephone and telegraph circles, and has been quite successful in this respect since it came into existence some five or six years ago under the first presidency of Mr. Charles P. Bruch, the assistant general manager of the Postal Telegraph-Cable Company.

The present officers of the Magnetic Club are as follows: president, F. W. Jones; vice-presidents, W. C. Burton, M. J. O'Leary, John Brant, F. D. Murphy; secretary and treasurer, R. J. Murphy; governing committee, C. A. Benton, M. R. Cockey, T. E. Fleming, M. H. Kerner, M. W. Rayens, D. W. McAneeny, R. E. Fagan, George F. Fagan.

National Electric Light Association.

In addition to the New England Passenger Association and the Trunk Line Association, the Central Passenger Association and the Southeastern Passenger Association have made a rate of a fare and a third for the round trip from all points throughout their territory, for delegates and friends attending the twenty-seventh convention of the National Electric Light Association, to be held May 24-27, at Boston, Mass. Mr. Frank L. Perry will be in charge of transportation matters for Chicago and vicinity, and will arrange a special train to bring delegates to the convention.

Mr. Charles H. Hodskinson, chairman of the committee on hotel accommodations, reports that an unusually large number of rooms have already been assigned to members.

The following active members have been added to the roll of the association: South Manchester Light, Power and Tramways Company, South Manchester, Ct.; Marion Light and Heating Company, Marion, Ind.; Rawson Light and Power Company, Leicester, Mass.; Monterey Light and Power Company, Monterey, Mex.; Herkimer Light and Power Company, Little Falls, N. Y.; Lockport Gas and Electric Light Company, Lockport, N. Y.; Olympia Light and Power Company, Olympia, Wash.; East River Electric Company, Bluefields, W. Va.

The following companies have been added as associate members: Indiana Rubber and Insulated Wire Company, Jonesboro, Ind.; Garton-Daniels Company, Keokuk, Iowa; Wagner Electric Manufacturing Company, St. Louis, Mo.; the Emerson Electric Manufacturing Company, St. Louis, Mo.; C. W. Hunt Company, West New Brighton, N. Y.; Sanderson & Porter, the Holophane Glass Company and the Electric Carriage Call Company, Incorporated, New York city.

The Union Engineering Building.

The conference committee of the Union Engineering Building will place the programme of competition in the hands of the architects during the present week. Professor W. R. Ware, as professional adviser to the committee, has been of very great assistance, and the plans submitted in the competition by the selected architects and by those who enter the open competition are to be in the hands of Professor S. R. Hutton, secretary of the committee, by June 15.

The Engineering Building on Thirty-ninth street, about midway on the north side of the block, will occupy 10,500 square feet exclusive of the fifteen square feet reserved under the city ordinances. The outside dimensions of the land are about 125 by 100 feet. Mr. Carnegie has bought and reserved a residence to the east of the building, which will be maintained at its present elevation so as to protect the air and light of the building on that side. While the general plans of the building are already well known, it may be stated that there will be at the top of the building three stories held for the use of technical societies invited to participate in the benefits of the building. Three other similar floors will be reserved, one each for the American Institute of Electrical Engineers, the American Institute of Mining Engineers, and the American Society of Mechanical Engineers. These floors will make ample provision for offices, and each will have a large reception room, as well as board and committee rooms. Below this will come the library. Next below will come a large main auditorium floor which will seat from 1,200 to 1,500 people, with 1,000 on the floor and about half as many additional in the galleries. This floor will preferably be as near the sidewalk as possible, and may have above it or below it a number of small meeting rooms, seating audiences of from 500 down to 100. There will be six such rooms, and these as well as the large room will be thoroughly equipped with gas, compressed air, steam, water, electricity, etc., for the conduct of experiments and demonstrations.

Lounging and smoking rooms will be provided, and there will also be a number of special banquet rooms, and facilities for serving occasional collations. The floor on the street level will be appropriated mainly for administration purposes, with three coat rooms capable of taking care of 1,500 garments at once, a ladies' dressing room, a bureau of information, public telephone and telegraph offices, post office, sales department and shipping and receiving offices for books, publications, etc. Below this floor will come the basement and subbasement, with provision for storage purposes, machinery, coal and operative apparatus.

There will be three elevators in the building of large capacity, one being able to take care of freight. The library floor will be laid out so as to accommodate not only the present consolidated libraries of 50,000 volumes, but a comprehensive collection of six or eight times that number. On this floor there will also be a number of reading and reference rooms.

For the purposes of the Engineering Building and the Engineers' Club regarded as separate structures, it is proposed to expend about $1,000,000, leaving the other $500,000 for tearing down old buildings, excavating, architects and engineers' fees, machinery and equipments.

The Engineers' Club will have a frontage of fifty feet and a depth of 100 feet, the front to be on Fortieth street and Bryant Park. There will be kitchen accommodations, dining room and sleeping room accommodations for the members. In addition to this, there will be a large billiard room, general reception room and meeting room, and library. There will also be telephone booths, storerooms, wine cellar, stewards' rooms and café.

The Underground Electric Railways Company of London.

In a circular dated London, April 5, Mr. Charles T. Yerkes, president of the Underground Electric Railways Company of London, Limited, says that the engine-room and switchboard galleries in the power-house at Lots road and Chelsea creek are entirely finished. The cranes working over the engine room are up and doing the work of installing the machinery. The condensers and air and circulating pumps are being put in very rapidly. The switchboard is about three-quarters finished. The foundations are entirely completed and waiting for the turbo-generators. All the steel frame is finished, and the brickwork will be finished in about one week.

In the boiler room the first group of eight boilers is installed. Work on other groups is in progress. All of the chimneys are entirely finished. The coal bunkers are well on to completion. The outside coal-handling plant is now being erected, and the large basin and gates are under way and will be finished in June. The oil-cooling plant is about finished. There are now at work on this building between 900 and 1,000 men.

Concerning the three-phase transmission line to Earl's Court, all of the ducts and manholes are completed, and the cables are being drawn in and will be finished in May.

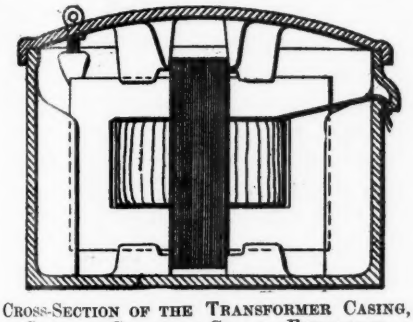
The contractors have finished the substation buildings at Whitechapel, Putney, Hounslow and Sudbury, and machinery is now being delivered for the first two named. The buildings at Mill Hill Park and Ravenscourt Park will be finished shortly, as well as Earl's Court. The South Kensington station will be finished in June, and the remaining three in September.

Respecting the district railway equipment, practically all of the work is completed west of Turnham Green Junction. Between the latter place and Studland Road Junction the work is almost finished. The Putney Bridge line is finished, except for the cables, and the work of drawing these into the ducts has been commenced. On account of the rearrangement of the line between West Kensington and Hammersmith, in order to allow the Piccadilly & Brompton line to reach Hammersmith, a good deal of electrical work remains to be done in that section. From West Kensington to Charing Cross the only work that remains to be completed is the drawing in of the cables. The ducts are completed under all platforms as far east as Aldgate. Conductor rails are practically distributed to Bow, and a good deal of work has been done toward placing them on insulators between Charing Cross and Bow. The automatic signal system is well in hand over the entire district railway. The grading for the new depot and car-sheds at Mill Hill Park is being taken care of at the rate of 6,000 yards a week, and the foundations for the buildings have been commenced.

Regarding the tunnels, the whole of the tunneling on the Baker Street & Waterloo Railway has been completed between Baker street and Waterloo station. The extensions to "Elephant & Castle" and also to Paddington are progressing rapidly. The lift shafts are all sunk, as well as the stair shafts, and stations are now being built at different sites on the street fronts. The Charing Cross, Euston & Hampstead Railway is progressing rapidly. Forty per cent of the single-running tunnels is completed, thirty per cent of the station tunnels, and fifty per cent of the lift shafts. Of the single-running tunnels of the Great Northern, Piccadilly & Brompton Railway, sixty per cent has been completed, fifty per cent of the single station tunnels, sixty-five per cent of the lift shafts, and ten per cent of the stair shafts.

Electrical Patents.

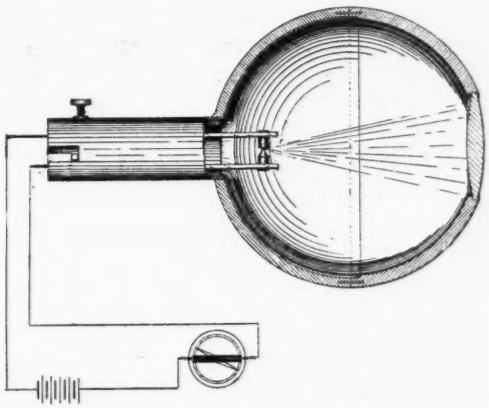
Mr. Walter A. Hall, of Lynn, Mass., has assigned to the General Electric Company, a corporation of New York, a patent recently obtained by him on a transformer. In building up the core of the transformer two different sizes of sheet-iron laminæ are used. Each complete lamina is composed of two pieces, a main U-shaped piece and a rectangular end-piece. The width of each leg of the large U-shaped piece is the same as that of the winding-space between them, and the length of the space is preferably twice its width. One leg is full length, the other only as long as the winding-space. The width of the lower integral end and of the separate upper end-piece is equal to the width of one leg. The length of the end-piece is equal to the width of one leg



Cross-Section of the Transformer Casing, Showing Core and Coil in Elevation.

plus the width of the winding-space. The small U-shaped pieces have legs whose width is one-half that of the legs of the larger pieces. The integral end and the end-piece are both of the same width as the legs. The total length of the smaller lamina is less than that of the larger one by an amount equal to the width of the end. The winding-space is of the same dimensions as the winding-space of the larger laminæ. The larger laminæ after suitable treatment are laid together coincidently until the cross-section of each leg is square. The mass is then pressed in a powerful hydraulic or other press and is then clamped in any suitable manner to retain it in shape. The smaller laminæ are laid up until the thickness of the legs is the same as that of the legs of the larger laminæ. To form the core of the transformer, two bundles of the larger laminæ are placed edge to edge in the same plane, and two bundles of the smaller laminæ are placed at right angles to the bundles of the larger laminæ, one edge of each bundle of the smaller laminæ abutting against the meeting edges of the bundles of the larger laminæ and the bottoms of the winding-spaced being all in the same plane. The core thus formed has a central leg cruciform in cross-section, two opposite legs square in cross-section, and two opposite legs rectangular in cross-section. The coil is preferably composed of two portions; an inner octagonal portion, composed of one or more secondary windings, and an enclosing primary winding, and an outer portion, consisting of a primary winding, surrounded by one or more secondary windings, all wound in substantially square form with rounded corners of large radius. The inner portion fits closely upon the cruciform central leg of the core, leaving triangular ventilating or oil-circulating spaces at the corners, and the combined thickness of the two portions just fills the winding-spaces, leaving crescent-shaped ventilating or air-circulating spaces between the rounded corners and the flat sides of the inner portion. The several windings are fully insulated from each other and from the core. The secondary windings are all connected, so as to form one winding, and the two primary windings are also connected. After the coil has been slipped over the central leg of the core, and seated on the bottom of the winding-space in each branch of the core, the end-irons are placed in position, and the core and coil are assembled in a box or casing which is filled with oil. In order to secure them in place, the box has internal lugs on its sides, between which the ends of the core branches are received. Wooden wedges are driven in between the lugs and the core to fasten the latter securely. On the bottom of the box are lugs preferably tapered, to compress the laminæ as the bottom edges of the core enter between the lugs. The cover has lugs, similar to those on the bottom of the box, and when the cover is drawn down by suitable fastening devices, the lugs clamp the core at the top.

A detector for electrical disturbances has been patented by Jagadis Chunder Bose, of Calcutta, India, who has assigned a one-half interest in the patent to Sara C. Bull, of Cambridge, Mass. The object of the invention is to improve the sensitiveness and quickness of response of detectors and coherers for the reception of electrical disturbances, Hertzian waves, light-waves, etc., and according to the present invention it is effected by subjecting the sensitive substance of a coherer or detector to certain methods, influences or agencies which will have the effect of removing this distortion, thus hastening the recovery of the substance. For instance, the sensitive substance may be subjected to torsional distortion by imparting to the tube or medium containing or carrying the sensitive substance either a one-directioned or an oscillatory or vibratory twist. In order that this may be conveniently accomplished the substance is placed in an elastic tube or medium, which has the effect of facilitating the action of the twist upon the substance and of ensuring quick recovery, or with the same object in view, the mass forming the receiver may be subjected to certain forces, physical surroundings, and conditions suitably adjusted and applied, whereby the mass becomes more responsive to electric disturbances, including Hertzian waves or other forms of radiance. The facility of response may also be increased by allowing various agencies to produce a tendency toward distortion on the verge of signaling or reception of the radiation, the radiation itself precipitating the



View of Instrument for Detecting Electrical Disturbances, Connected up in an Electric Circuit with a Galvanometer.

change. It is also possible to dispense with the mechanical means for producing recovery of the coherer or detector by using sensitive substances in which the recovery is automatic. Mr. Bose has discovered that certain substances possess the property of self-recovery; namely, those which give a characteristic curve representing relative resistances. Of the substances which give a characteristic curve some have the property of presenting a decreasing resistance to the passage of the electric current with an increasing impressed electromotive force, while others have the opposite property; namely, that of presenting an increased resistance as the impressed force increases. An example of such substances includes galena, tellurium, magnesium, lead, tin, potassium, allotropic silver. Chromium, manganese or zirconium may also be used as the sensitive agents in coherers or detectors. Ammonia-vapor or carbonic gas may be used in small proportions to stimulate the action of the sensitive agent and in large proportions to depress it. A novel apparatus is also provided for use in detecting light-waves, Hertzian waves and other radiations. This apparatus may be regarded as an artificial retina. In this apparatus a sensitive substance having a characteristic curve is employed.

Reviews of Current Engineering and Scientific Literature.

An Iron-Wire Rheostat.

The iron-wire rheostat described in this article was designed by M. Weber, engineer of the Nancy (France) central station. M. F. Loppé gives the details of construction and some data showing its performance. The rheostat was designed to test a 1,000-kilowatt 500-volt generator. It consists of six coils of iron wire three millimetres in diameter, the spiral being six centimetres in diameter. These are immersed in a pine box containing water, and between the individual coils wooden partitions are slipped. The wires are connected to two copper rods by long iron bolts projecting into the water, the copper being held above the level of the water. Water is run through the rheostat during use. No electrolytic action takes place. This rheostat has absorbed 1,660 amperes at 500 volts, this being 276.67 amperes per coil. A suitable density of current in the wires may be determined by the formula: $I = k\,x\,d\,\frac{3}{2}$, in which k has the value 53.2. The rate of flow of water is two metres per second. The temperature rise was sixty degrees.—*Translated and abstracted from L'Industrie Electrique (Paris), April 10.*

A New Mineral from Ceylon.

Sir William Ramsay has secured five hundredweight of a mineral found in Ceylon, and which he supposed contained uranium. This he is having analyzed, and is studying in order to determine the constituents. When heated alone it gives off 3.5 cubic centimetres of helium per gramme. When fused with hydrogen potassium sulphate, the amount is increased to 9.5 cubic centimetres. From this source he has already stored about twelve cubic feet of pure helium. The mineral contains but eight to twelve per cent of uranium—much less than was expected. The other main constituent was believed to be zirconium, but the density of the mineral rendered this improbable. There is less than one per cent of thorium, nor does the mineral contain an appreciable amount of cerium, lanthanum and didymium. Fractionation shows that the oxalate precipitate gives equivalents between 25 to 44.7. By far the major part of the material has the last-mentioned equivalent. This would indicate the presence of a tetrad element with an equivalent approaching 44.7, and for this there is a gap in the periodic table between cerium and thorium. One at least of the elements present would probably have an atomic weight of about 177, preceding tantalum in the horizontal row of the periodic table. The author is at present mapping out the spectrum of these new bodies. There is a small trace of radium present, due to the disintegration of the uranium. The radioactivity due to this source is certainly not five per cent of the total.—*Abstracted from Nature (London), April 7.*

Measurement of the Resistance of Insulators During Operation.

A method is here described by M. L. Pillier for examining electric railway insulators during the running of trains, thus enabling all the time of shutdown to be given to making repairs. This system is only applicable where there are two insulating parts separated by a conductor. This is usually the case with third-rail insulators, which rest on an iron shoe on the crosstie. For making a test, a high-resistance voltmeter (the resistance being known) is all that is required. A measurement is first made of the voltage between the conducting rail and the return rail. This is designated as E. Then measure the fall of potential from the conducting rail to the insulator base. Call this D. Then measure the fall of potential between the shoe and the running rail, designating this as d. The following equations then hold:

$$k\,D = k\,E\,\frac{\frac{GR}{G+R}}{\frac{G\,r}{G+r}+R} \qquad (1)$$

$$k\,d = k\,E\,\frac{\frac{GR}{G+R}}{\frac{G\,r}{G+r}+R} \qquad (2)$$

in which G is the voltmeter resistance, R the resistance of the insulator, k a constant, and r the supplementary resistance, usually that of the tie. Solving these equations, the following expression gives the resistance of the insulator:

$$R = G\,\frac{E-(D+d)}{d}$$

In this work it is not necessary to have a carefully calibrated voltmeter, although it is essential that the scale deflection should be proportional to the applied voltage. By simplifying the formula in the following way a mental calculation of any set of readings is easily made, and the insulation resistance estimated.

$$R = G\left(\frac{E-D}{d}-1\right)$$

For this work a voltmeter having a scale reading of 600 volts, with an internal resistance of 120,000 ohms, permits resistances of fifty megohms to be measured, with an error of about two per cent.—*Translated and abstracted from L'Électricien (Paris), April 9.*

Design of Small Dynamos.

Mr. J. W. Burleigh is of the opinion that the design of small dynamos has not received the attention of technical journals which it justly deserves. Formulæ for various details of machines have appeared from time to time, but it rarely happens that a specific output is chosen, and that the principal calculations for the electrical details are given in concise form. It is important that motors having the same output, but for different voltages, should be constructed with similar carcasses. Usually this can be done with voltages of 110, 220 and 440, the windings in each case being varied to suit each voltage. For machines not exceeding ten kilowatts, the author believes the two-pole type is the best. He designs a set of 2.4-kilowatt dynamos to run at a speed of 1,200 revolutions per minute, suitable for the three voltages mentioned. He gives a number of short cuts in design, and a complete table of data for the three machines.—*Abstracted from the Electrical Review (London), April 8.*

Disruptive Discharges at Very High Voltages.

La Compagnie de l'Industrie Electrique has recently constructed three continuous-current generators of the Thury type, which are each capable of generating 25,000 volts. M. J. de Kowalski has had the privilege of using these three machines connected in series, to study high-tension direct-current discharges. As these machines are capable of delivering one ampere, ordinary electromagnetic instruments were used for making measurements. The three were connected in series, and, through a very high resistance, to a discharge gap. In parallel with the gap a large condenser was connected, which preserved a constant potential at the gap during discharge. Two types of discharge were observed—disruptive and the arc. In order

that an arc may persist, the resistance in series must not exceed a certain value. For a given spark distance and fixed potential, the resistance must be greater as the capacity of the condensers decreases, for sparking to take place. The discharge takes place between a sphere twenty millimetres in diameter and a plate 158 millimetres in diameter, both made of brass. Tables of results are given, which show that the ratio of the voltage to the gap across which sparking would take place decreases as the voltage and the gap increase. Experiments were also made with arcs playing between two brass rods. This arc had a small current density, and has the same general characteristic as the alternating-current arcs. There is a stable and an unstable zone. In the stable zone the ratio between the length of the arc and the fall of the potential and the intensity of the current seems to be a linear function. The limiting length of the stable arc depends upon the intensity of the current and the difference of potential at the terminals of the machine. In the unstable zone the arc has an unsymmetrical aspect. It is nearly fixed at the cathode, but it travels rapidly over the surface of the anode.—*Translated and abstracted from L'Eclairage Electrique (Paris), April 9.*

The Adaptability of Electric Driving.

This gives an abstract of a paper written by Mr. B. Longbottom, and read before the Manchester Association of Engineers (England). The author compares mechanical driving by means of line shafts driven by gas or steam engines, with electric driving by individual or group motors. From many tests, he finds that the loss in the mechanical system is, on an average, forty-five per cent of the full load of the engine. Considering an electrical system requiring 100 horse-power at three-quarters load, he assumes an efficiency of eighty-two per cent at the engine-room switchboard. The loss is two per cent at three-quarters load in the cables, making the efficiency to the motors eighty per cent. The motors most suitable for this work would be five and ten-horse-power machines, the average being seven and one-half horse-power. At three-quarters load, the efficiency of such a unit would be eighty-three per cent, giving a total efficiency at the motor pulleys of 66.5 per cent. Where individual driving is resorted to, there is a slight further loss, due to the belt or gear. For a motor driving a group of machines, the loss in the short line shaft must be allowed for. He assumes that one-third of the machines in this plant will be used for group-driving, and he allows a loss of twenty per cent in the shaft and belts. This gives an efficiency of sixty per cent for the electrical distribution, and fifty-five per cent for the mechanical. Assuming this plant to be working at full load, due to added machinery, the efficiency would be fifty-seven per cent; but the added shafting will reduce the efficiency at three-quarters load to forty-three per cent, and to ten per cent at half load. Under similar conditions, the electric drive would give eighty-two, eighty and seventy-five per cent efficiencies for full, three-quarters and one-half load, respectively. So far no allowance has been made for the reduction in loss due to shutting down unloaded motors, which would considerably improve the efficiency of the electrical system. In another case, assuming the full load to be 400 horse-power, he shows that if electrical distribution be used in place of steam, the decrease in power required will be twelve, nineteen and twenty-nine per cent at full, three-quarters and one-half loads, respectively. The author then considers the proper grouping of machines, and the selection of suitable driving motors. Too many machines should not be driven by the one motor, and it should be seen to that they are not spread over a large area. Another advantage of the electrical system lies in the fact that, due to specialization, it becomes advantageous to group certain machines in different parts of the main shop, or even in separate rooms. This is easily done, as the location of one group of machines does not in any way affect the position of another. The machinery may then be grouped so as to obtain the greatest output, at the same time without increasing the cost of transmission. Other advantages of this system are the ease with which portable tools may be driven, and with which the plant may be enlarged.—*Abstracted from the Electrician (London), April 8.*

BOOK REVIEWS.

"La Télégraphie Sans Fils." André Broca. Paris. Librairie Gauthier-Villars. Paper. 235 pages. 4¾ by 7¼ inches. 52 figures. Supplied by the ELECTRICAL REVIEW at $1.25.

In the 228 pages of this book the student of the art of "wireless" will find a good deal of interesting matter couched in language that sustains the reputation of French scientific writers for clearness. While the book is hardly broad enough in scope to be recommended as a general treatise, the author's ingenious use of mechanical analogies in his explanations of phenomena, the chapters on wave propagation and the part played by vertical wires, and the speculative chapter on the advantages and disadvantages of space telegraphy as compared with older methods, are noteworthy. The theory of the action of the coherer in several of its practical forms, and a discussion of the Rutherford magnetic hysteresis detector, occupy the greater part of the chapter on receiving devices. In addition to the above features, the illustrations, a good index in the form of chapter headings and subheadings, and the interesting personal views of the author help to make the book in its present edition a real contribution to the literature of wireless telegraphy.

"Essais Industriels des Machines Electriques et des Groupes Electrogènes." F. Loppé. Paris. Gauthier-Villars, Imprimeur-Librarie. Paper. 284 pages. 6½ by 10 inches. 129 figures. Supplied by the ELECTRICAL REVIEW at $2.

This book has resulted from the author's work at the Ecole superieure d'Electricité de Paris. It discusses the object of the various tests which are made on electrical machines, the proper methods of conducting these tests, and the arrangements in loading down motors and generators. No descriptions of instruments are given, except when something special is required, in which case details are included. The subjects considered are the organization tests, general methods of testing, tests of continuous-current machines, tests of alternating-current machines and tests of generating groups. Under each subject the various tests applicable to that type of machine are given in detail. The book includes a number of useful physical tables and a set of model data sheets showing suitable arrangements for keeping records.

"Electricity and Matter." J. J. Thomson. New York. Charles Scribner's Sons. Cloth. 162 pages. 5½ by 8 inches. 17 diagrams. Supplied by the ELECTRICAL REVIEW at $1.25.

This book is the outcome of the Silliman memorial lectures which were delivered by Dr. Thomson at Yale University in May, 1903. The author discusses the bearing of the recent advances in electrical science on our views of the constitution of matter and the nature of electricity. In treating the subject, he starts at the bottom and builds up our conception of the electric field as represented by Faraday's lines of force. Chapter two, on electrical and bound mass, considers the connection between the momentum in an electric field and lines of force. Chapter three deals with the effects due to acceleration of the Faraday lines of force, this taking up Rœntgen rays and light. Chapters four and five, upon the atomic structure of electricity and the constitution of the atom, explain the new ideas resulting from the discovery of the corpuscle. In the last chapter, radioactivity and radioactive substances are discussed. The book is written in a rather popular style, mathematical demonstrations being avoided wherever possible.

INDUSTRIAL SECTION.

ILLUSTRATED DESCRIPTIONS OF NEW AND STANDARD ELECTRICAL AND MECHANICAL APPARATUS.

Push-Button Telephones.

The Anders Push-Button Telephone Company, 136 Liberty street, New York city, is the legally authorized name of the company succeeding the American Push-Button Telephone Company. On and after May 7, 1904, the company will adopt the new name.

The accompanying illustrations show in detail the Anders push-button telephone. Fig. 1 shows the complete instrument, the transmitter and receiver being dissected, showing the parts in condition for assembly. Referring to the numerals designated on Fig. 1, 1 is the fibre plate for the wires to pass through before connecting to the telephone, this also forming the protection of the button, switch, etc.; 2 is the transmitter-base, switch, etc.; 3 is the receiver cap; 4, diaphragm; 5, receiver base, etc.; 6, button-cap; 7, button. Fig. 2 shows the front and back views of the jack and plug switch blocks for intercommunicating systems. Fig. 3 shows the complete fourteen-point intercommunicating desk-stand.

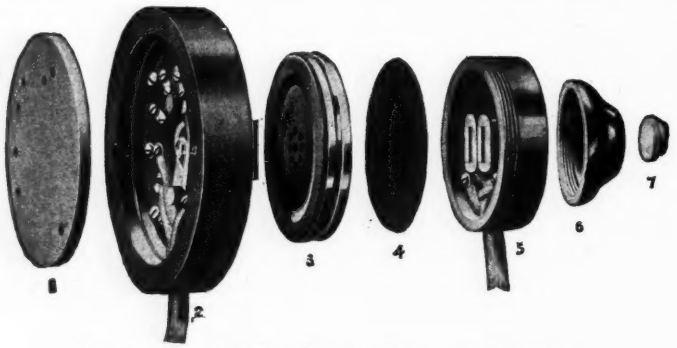


FIG. 1.—COMPLETE PUSH-BUTTON TELEPHONE DISSECTED.

FIG. 2.—JACK AND PLUG SWITCH-BLOCKS.

The transmitter movement is of the solid-back type, with self-contained granular carbon and electrode-holder of the button type, having a metal diaphragm secured to the front of the electrode button. The granules are of hard, polished carbon, and will not pack or deteriorate after long terms of use. Diaphragm and carbon granules are carefully selected, to mutually combine to form a transmitter of the greatest efficiency, combining simplicity, durability, ease of access for the purpose of inspection or repairs, and working up of details. The base of the transmitter is fitted with an automatic switch, which is provided with pin-point springs.

In the hard rubber composition base are cast metal lugs fitted with machine screws and washers threaded into the lugs for the receiver and transmitter cord, switch and spring connections, and also for the bell line and battery connections, the base being formed and cast in a steel die the same as the receiver. On the face of the transmitter base is a nickel-finish metal plate with two ear lugs to engage in the grooved metal ring which is cast over the receiver cap which holds the receiver in place when it is not in use. The placing of the receiver in the ear lugs engages the lever of the automatic switch, which, in turn, changes the circuit springs on the back of the transmitter base, cutting out the transmitting and receiving circuits and cutting in the single bell circuit. There is a small fibre disc fitted in the back of each transmitter base, the disc having a number of holes punched through to correspond with the lugs in the base, to which the various wires are to be connected.

The dimensions of the complete telephone overall, consisting of transmitter, receiver and connecting lugs, are: diameter, three and one-half inches; depth, two and one-quarter inches; depth of telephone overall, mounted on intercommunicating switch block of the wall type, three and one-quarter inches. The telephones are wired and fitted for straight-line intercommunicating switchboard or return-call annunciator central station and selective-ringing common-battery systems.

Stock switch blocks for use in connection with the telephones of the intercommunicating type are of the improved jack and plug type. The springs used in the jack connections are made of the best phosphor-bronze. The angles are turned, and when the plug is inserted in any of the jacks the tip engages the tongue of the jack spring, which has a double spring bearing. The switch blocks are finished and carried in stock in mahogany and oak. Other finishes can be fitted when desired.

FIG. 3.—FOURTEEN-POINT INTERCOMMUNICATING DESK-STAND.

The switch blocks are made in one solid piece, of thoroughly seasoned wood, and

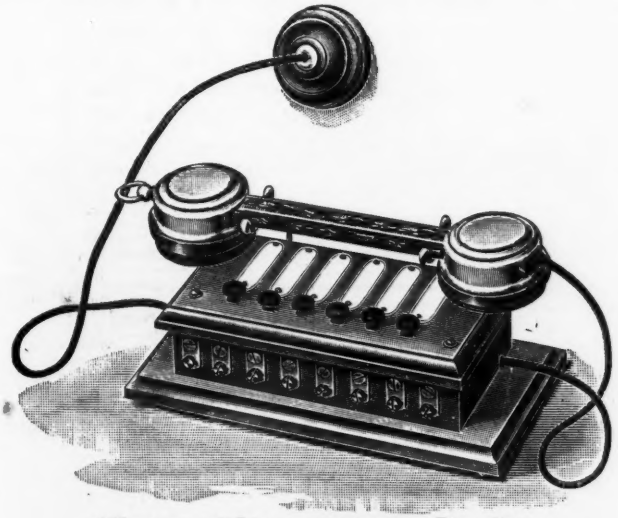
of substantial construction, and will not warp. The diameter is five and seven-eighths inches; depth, seven-eighths of an inch. They are fitted with from five to eighteen jack connections. The plug is suspended from the block by a silken cord, there being no electrical conductor in this cord. It is merely attached to the plug to allow it to be suspended from the block when not in use.

The "Metaphone."

The accompanying illustrations show several forms of a new type of intercommunicating telephone manufactured by

"METAPHONE" CONNECTED WITH ALARM BELL.

the Electric Utilities Company, Fuller Building, Twenty-third street and Broadway, New York city. The "Metaphone"



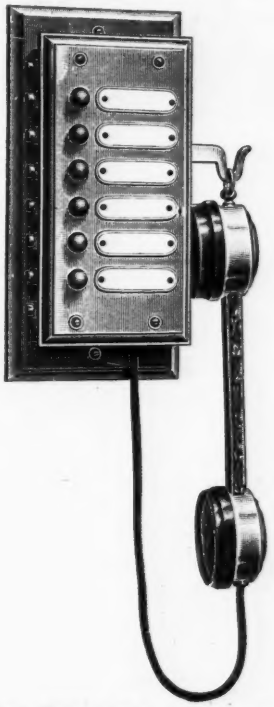
"METAPHONE" INTERCOMMUNICATING DESK SET.

is primarily a telephone ready for attachment to any electric bell installation, and is designed particularly for use in houses, apartments, clubs, offices, hotels, factories, ships, etc. The apparatus consists of a transmitter and receiver mounted on opposite ends of a short metal handle, the wires leading out from the transmitter end. One instrument, the push-button

PUSH-BUTTON AND "METAPHONE."

"Metaphone," is to be attached to any push-button at one end of a circuit. Another, designated as the bell "Metaphone," is to be attached to the bell or bell and annunciator combined at the other end of the circuit. No alteration is required to the push-button, bell or annunciator.

The "Metaphone" intercommunicating sets permit a number of stations to be so connected that from any one station direct telephonic connection can be automatically established with any other station, without the necessity of a central switchboard or switchboard operator. The connection is made by taking the "Metaphone" from the hook of the wall set and depressing the button of the desired station. The call is made by several depressions of the calling button, which produces a sharp knocking sound in the "Metaphone" to which connection has been made. Conversation takes place by putting the receiver end of the "Metaphone" to the ear and talking past (not into) the transmitter, which is the end from which the wires lead. The connection with the distant station is automatically broken at the end of the conversation by replacing the "Metaphone" on the hook. If, after talking to one station, it is desired to talk to another, the button



"METAPHONE" INTERCOMMUNICATING WALL SET.

of the desired station is depressed, which makes the connection, and, at the same time, automatically disconnects the station previously connected. Only one battery is used, making the installation very simple and the battery maintenance slight.

The most satisfactory way in which to make comparison of the relative cost of various kinds of power is by the cost per horse-power per month. Steam, electricity and water power are the three kinds most generally in use in the mining regions of the West. In some districts there is also power derived from gas, gasoline, distillate and other types of engines. No comparison of the relative cost of water, steam and electric power can be given without a complete knowledge of conditions obtaining at the place where the power is to be employed.

A New Fibre Lamp Shade.

The accompanying illustration shows the new "Fiberlite" shade and holder manufactured by the Applied Device Company, of Springfield, Mass. The holder is made of heavy wire, all in one piece,

NEW FIBRE LAMP SHADE.

and clamps to the socket with a catch similar to a guard. There are no screws used. The holder fastens to the inside of the shade, and any attempt to pull it off causes the holder to cling more tightly to the shade.

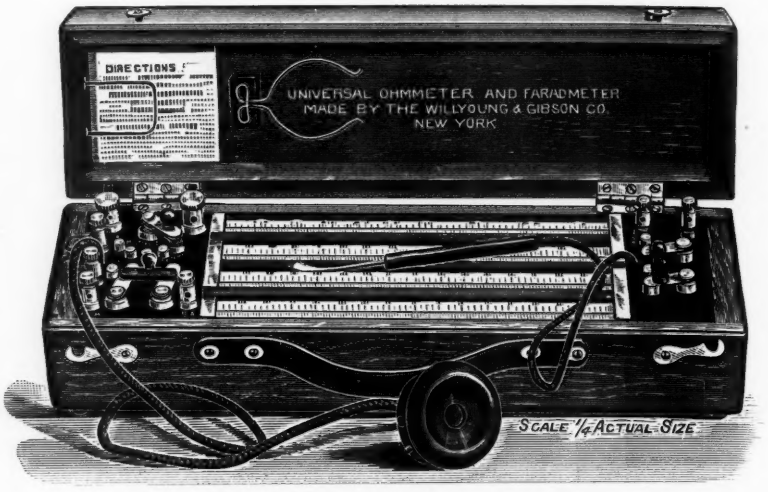
The shade is made from a fibre similar to that used for the lining of incandescent lamp sockets. This is mottled green on the outside, and pearl gray on the inside. The fibre is of the same weight as aluminum, and is similar in appearance. It is finished under pressure, which gives it a glossy surface and makes it a good reflector of light. While it is so tough that the edges will not break, it is springy and will not crush out of shape.

Electricians' Tool Chests.

The accompanying illustration shows the electricians' tool chest manufactured by William Vanderman, of the Vander-

ELECTRICIANS' TOOL CHEST.

man Plumbing and Heating Company, Willimantic, Ct. These patented steel tool chests are made from one-sixteenth-inch cold-rolled sheet steel with malleable iron corner pieces and hardwood braces. They are fitted with heavy wrought-iron hinges and hasp, and the cover is so arranged as to be held open by a support from the back of the chest. Each chest is furnished with a first-class brass lock and two keys, and bolts to screw down the cover at the front corners. The chests are painted, well

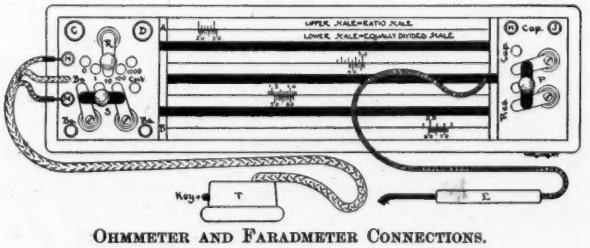


UNIVERSAL OHMMETER AND FARADMETER.

proportioned and ornamental in design. They are made in six styles, and four sizes to each style.

The Willyoung Universal Ohmmeter and Faradmeter.

The accompanying illustration shows a new model of this well-known instrument. The present apparatus has been upon the market for about a year, and has already found extensive use among telephone and electric light men, in shops and in scientific laboratories. A general view of the instrument is given in Figs. 1 and 2. The apparatus is a simple application of the Wheatstone bridge principle, and has had a number of predecessors of various makes. The Willyoung instrument, however, is



OHMMETER AND FARADMETER CONNECTIONS.

claimed by the manufacturer to possess certain features of detail which make it a distinct departure from anything which has heretofore been made.

There is a slide wire in four sections, each ten inches long, or forty inches in all. There are ratio coils of 1, 10, 100 and 1,000, any one of which is set by the use of a small switch. The bridge wire is laid on an engine-divided scale which is direct-reading in ohms, and is only multiplied by the bridge ratio to give the actual values of unknown resistance. A telephone is used as an indicator instead of a galvanometer, and a finger held in the hand is applied to the ohmmeter wire and touched from point to point until no click is heard in the receiver. For non-inductive resistances, and also for electrolytic resistances, throwing a switch substitutes a small induction coil, concealed in the bottom of the instrument, for the battery.

To measure electrostatic capacity, the double switch at the right of the instrument is thrown from "Res" to "Cap." This inserts a one-tenth microfarad standard, and the instrument is again direct-reading, as before, in microfarads. Besides resistances, electrostatic capacity, electrolytic resistance, etc., the instrument is arranged to make fault and location tests by any of the regular loop methods. Posts are provided for the use of an outside battery, if desired. The telephone may be instantly disconnected, and any desired galvanometer substituted for it. Instead of using either battery or induction coil, a straight alternating current may be used by connection to the posts provided.

Besides the direct-reading scale, which

is printed just underneath each wire, there is also a uniformly divided scale of 1,000 parts, which lies just above the wire.

The weight of the instrument is about seven pounds; and its dimensions are sixteen and three-quarters inches by five inches by four and one-half inches overall. The same apparatus, but without the portion required for capacity measurements, is sold as a universal ohmmeter. This instrument weighs about five pounds and measures fourteen and three-quarters inches by five inches by four and one-half inches overall.

The Willyoung & Gibson Company, 40 West Thirteenth street, New York city, is the manufacturer of this apparatus.

Blue-Printing Outfits.

The electric blue-printing outfits shown in the accompanying illustrations show the more recent developments in this class of apparatus manufactured by the General Electric Company, Schenectady, N. Y. These outfits are designed for the making of blue-prints by means of arc lamps, and are capable of making two prints forty-eight by thirty-six inches or a larger number of small prints at one time. The frames are cylindrical in shape. The sides of the frames are made of curved plate-glass, against which the tracings and blue-prints are placed; canvas curtains, operated by foot levers, hold them in position. This arrangement holds the tracings firmly against the glass, ensuring good contact between the tracing and blue-print. The electric current is thrown on automatically by the foot lever, thus avoiding excessive waste.

The frame is light, strong and durable, being constructed of angle iron and sheet steel; its light weight renders it practically easy to move from one place to another as the occasion demands. By placing thin metal bands horizontally and vertically across the glass to hold the tracings, it is possible to make as many as thirty-two eight by ten and one-half inches prints at one time. This attachment obviates the necessity of removing the tracings until all the desired prints have been made. These outfits can be used on either direct or alternating-current circuits, using in either case the company's enclosed arc lamps with clear globes. Exposures are governed entirely by the condition of the tracing and the grade of blue-print paper employed, the average print, however, is obtained in from one and one-half to three minutes. It is stated that the General Electric Company, in its own blue-printing department, during the month of January, 1904, obtained without the aid of solar light 110,000 prints from an equipment of twelve frames.

ELECTRICAL BLUE-PRINTING OUTFIT OPERATED WITH ARC LAMPS.

METHOD OF SETTING UP A SERIES OF ELECTRICAL BLUE-PRINTING OUTFITS.

Electrical Opportunities in Paraguay.

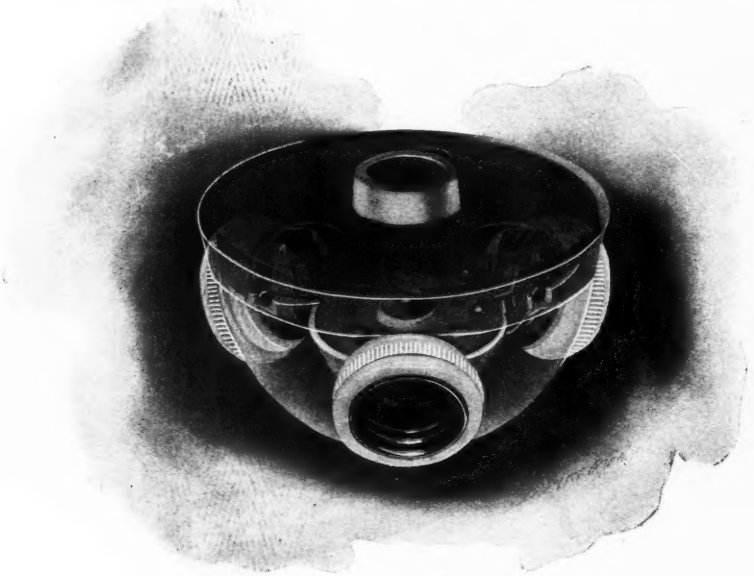
United States Consul J. N. Ruffin reports that an electric lighting plant has been established at Asuncion, Paraguay. If this enterprise is successful, it will be extended to supply motive power for driving electric fans and for other purposes. The consul has had many enquiries for catalogues and trade literature of electrical apparatus. Such literature should be accompanied with export prices, and should be written in Spanish.

The Use of Radium in Hospitals.

The annual report of the London Hospital for Diseases of the Skin shows that recent electrical discoveries are being used successfully in the treatment of skin diseases. The hospital is equipped with Finsen lamps, X-ray and high-frequency apparatus, and a quantity of radium. This department is in charge of Dr. T. J. P. Hartigan, who reports that the result of the greater number of the 144 cases subjected to the effects of radium exceeded expectations. Two cases of rodent cancer were practically cured.

The Dale Wireless Cluster.

The accompanying illustration shows the Dale wireless cluster for multiple or series connection. This device has several features of importance, as follows: it has the appearance of a fixture, at the same time having no sockets and employing no wiring; there is about seventy-five per cent fewer screws used with this cluster, and this eliminates the possibility of loose contacts. A pendant switch may be attached to this cluster by the most inexperienced person, and it requires a shade but fourteen inches in diameter to fully cover the lamps. This cluster was patented April 14, 1904, and the manufacturer states represents the acme of electrical and mechanical construction. The company has prepared a booklet describing in detail and illustrating in various ways this wireless cluster for different applications. The Dale Company is located at Ninth avenue, Thirteenth and Hudson streets, New York city.



THE DALE WIRELESS CLUSTER.

The Annual Meeting of the Joseph Dixon Crucible Company.

The annual meeting of the stockholders of the Joseph Dixon Crucible Company was held at the company's main office, Jersey City, N. J., on April 18. Out of a possible vote of 7,345 shares, there were 7,126 shares voted for the reelection of the old board, consisting of Edward F. C. Young, John A. Walker, William Murray, George T. Smith, Edward L. Young, George E. Long and Joseph D. Bedle. President E. F. C. Young, Vice-president and Treasurer John A. Walker, Secretary George E. Long were reelected by the directors. Judge Joseph D. Bedle was also reelected as counsel.

Farmers' Telephone Service.

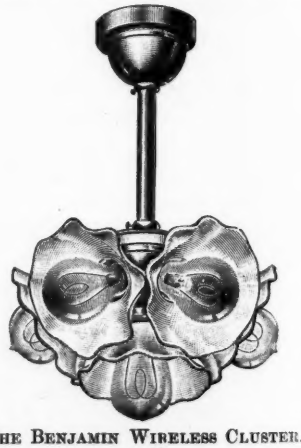
The Federal Telephone Company, with general offices in the Bissel Block, Pittsburg, Pa., is announcing the following annual rates on four-party lines to farmers who own or will purchase and maintain their own telephones, and own or will build a pole line and string iron or copper metallic circuits to the point on existing Federal pole lines where connections can be made with Federal metallic circuits which will be strung to connect with the farmers' line: within one mile from exchange borough limits, $10 each; within two miles, $12; within three miles, $14; within four miles, $16; within five miles, $18; within six miles, $20; within seven miles, $22; within eight miles, $24. These rates are made on the understanding that connections are made on existing Federal pole lines, and that the rental in each case for each set of subscribers will be paid semi-annually in advance from the date service is given. The mileage will be estimated on the basis of forty poles to the mile, counting from the borough limits of the borough in which is located the Federal exchange to which the respective subscriber is connected. Subscribers to this service will be entitled to the same free radius that other subscribers receive at the respective exchanges.

Street Railways.

The total mileage of city, suburban and interurban track in the United States is 24,561 miles. Of this, 281.4 miles are operated by horse cars, 142.2 miles by dummy engines, 267.8 miles by the cable, while 23,869.6 miles are operated electrically. For the operation of the horse-car lines 7,923 horses and mules are employed; for the dummy lines there are 475 dummies and locomotives; for the electric lines 52,119 motor cars are required; while for all lines there are needed for operation 13,301 passenger and freight cars. The value of these properties may be judged from the fact that the capital stock amounts to the sum of $1,685,840,296; while the bonded debt is $1,180,313,809. The electrically operated roads have increased from 10,239 miles in 1894 to 23,869.6 in 1903. At the same time the lines operated by dummies and locomotives have decreased from 409 to 142.2; those operated by cable from 578 to 267.8, and those operated by horses from 1,950 to 281.4 miles. While the total mileage has not quite doubled in this period, the capital stock has increased over 150 per cent, while the bonded indebtedness has increased by even a larger ratio.

New Type of Wireless Cluster.

The accompanying illustration shows a new form of wireless cluster which the Benjamin Electric Manufacturing Company, Chicago, Ill., is supplying to the market. This consists of a wireless cluster having from two to five lamps in a circle and one straight down. The company has recently devised a shadeholder which is attached to the cluster by means of an insulating bushing or rings, and takes an ordinary two and one-quarter inch shade of suitable dimensions. This makes a substantial cluster and is attractive in appearance, having a hemispherical form. The effect can be changed by using shades of different form and appearance, to suit the desire of the purchaser. This style of cluster is used with many types of well-known lamps. By means of this shadeholder the ordinary types of the Benjamin cluster can be used with individual shades, as well as with the larger shades previously used with these clusters.



THE BENJAMIN WIRELESS CLUSTER.

A full line of the Benjamin products will be shown in its exhibit booth at the St. Louis Exposition, in section 25 of the Electricity Building.

CURRENT ELECTRICAL NEWS

DOMESTIC AND EXPORT.

TO OPEN A FESSENDEN WIRELESS TELEGRAPH STATION IN WASHINGTON—Professor Reginald A. Fessenden is building a station in Washington, D. C., for the commercial application of his system of wireless telegraphy. It is understood that efforts will be made to establish continued communication between such points as Washington and New York and other commercial centres. The apparatus will include the latest improvements devised by Professor Fessenden, and an important feature of his work will be the new barreter which he has invented, and which greatly increases the facility for detecting wireless electrical phenomena.

ARGENTINE ELECTRIC ROAD TO HAVE EQUIPMENT MANUFACTURED IN THE UNITED STATES—The Buenos Aires Grand National Tramways Company, Limited, the company organized with British capital, whose head offices are in London, and whose consulting engineers are Sir George Bruce & White, London, is about to convert its extensive horse-car system in the capital of the Argentine Republic to electric traction. The company operates about fifty miles of track, and the estimated cost of conversion is $4,000,000. The managing director, C. Dawney, resides at Buenos Aires, as does J. H. Wall, the general manager. It is stated that a large portion of the equipment will be purchased in the United States.

AMERICAN EQUIPMENT FOR JAPANESE ELECTRIC LIGHTING PLANTS—A number of contracts have already been closed for various equipments to be installed in Japanese electric lighting plants, mines, etc. Two 500-kilowatt Curtis turbines have been ordered for shipment to the Yokohama Electric Light Company, for the extension of its plant. The Tokio electric plant will also put in a 500-kilowatt turbine. A 300-kilowatt generator and three transformers, aggregating 360 kilowatts, will be built by the General Electric Company for installation in the Sumito copper mines. A 500-kilowatt General Electric generator, together with 600 kilowatts in transformers and a 165-kilowatt motor-generator, have been contracted for by the Kosaka Copper Mining Company. The generator will be driven by an 850-horse-power Leffel turbine.

ENGINEERS BEGIN WORK FOR OREGON WATER-POWER PLANT—The engineers for the power plant of the Washington & Oregon Power Company are now at work on the site of the proposed power station on the south fork of the Walla Walla river, near Milton, Ore. Construction will be pushed as fast as possible, and it is the intention to have the plant in operation by October 1. The proposition contemplates furnishing light and power to all of the country between Walla Walla and Pendleton. A main power line will be run from the plant on the Walla Walla river both ways to the two cities, and branch lines will be built to all of the smaller towns along the route, furnishing them with light and power. The Walla Walla Electric Light Works and the Pendleton Electric Light and Power Company were both bought out by a new company which is financed by Philadelphia capital, and incorporated under the laws of both Oregon and Washington.

LEGAL NOTES.

CHICAGO TELEPHONE RIGHTS—Judge Mack handed down an opinion on April 15, deciding that the restrictions of the original ordinance for cheap telephones applied to the territory afterward taken into the city, and that the Chicago Telephone Company should pay three per cent of its gross receipts on all of its lines to the municipality. Instead of paying $175 a year for telephones, subscribers outside of the old city limits will have to pay $150 a year under this ruling.

IOWA TELEPHONE COMPANY WINS ITS LOCAL TAX SUIT—The Supreme Court for the State of Iowa holds, that a telephone company can not be taxed locally upon its poles, wires and other tangible property in any county of the state of Iowa, when it has paid taxes upon the same into the state treasury. This is the opinion handed down in the case of A. W. Layman, treasurer of Polk County, against the Iowa Telephone Company. The holding affirms a decision of the lower court. The action was brought by the county treasurer to recover $610 assessed against the tangible property of the Iowa Telephone Company, situated in Polk County, the value of which is estimated at $40,000. This property, the company contended, was reported to the executive council for taxation and assessed by that body, the amount assessed being paid into the state treasury and was therefore exempt from local taxation.

NORWICH, CT., LOSES LONG-STANDING LIGHTING SUIT—The well-known case of the Norwich Gas and Electric Company against the city of Norwich, Ct., was decided on Thursday, April 14, by the Supreme Court, against the city. The suit arose over a disagreement in interpreting the compulsory purchase clause of the law passed by the general assembly in 1893, entitled "an act authorizing cities and other municipalities to establish plants for the manufacture of gas and electricity." About three years ago the city of Norwich passed a vote to buy out the Norwich Gas and Electric Company. The valuation which the company placed on this plant was claimed by the city to be exorbitant, and was refused. A commission was appointed, which fixed a valuation in advance of that claimed by the city, but which did not include a mortgage for $400,000. There has been, in connection with this case, one of the most stubborn legal fights in the history of the state. The case was finally carried to the Supreme Court. The finding here has been, that the city must pay $590,000, plus the appraised value of the supplies; or it must abandon the property and pay the company $190,000 and the value of the supplies, and then surrender it to the holders of the mortgage for $400,000. Frank T. Brown, of Norwich, and Henry Stoddard, of New Haven, represented the company, and Nathan Matthews, of Boston, and Gardiner Greene and J. T. Fanning, of Norwich, represented the city.

OBITUARY NOTICES.

MRS. JULIA R. BALDWIN, aunt of Mr. Cyrus O. Baker, the well-known platinum refiner, died suddenly of heart failure in Newark, N. J., on Thursday, April 21. Mrs. Baldwin was sixty-two years of age, and dropped dead on the street while talking with some friends.

MRS. MARY PECK, widow of Charles Peck, died at the Laurel House, Lakewood, N. J., at five o'clock on the morning of Sunday, April 17. Mrs. Peck was in the best of health, but through an accident sustained a fatal injury on the Wednesday evening previous. Mrs. Peck was the mother of William Peck, of New York, an importer, and of Edward F. Peck, general manager of the Schenectady Railway Company, Schenectady, N. Y. Her daughter, Mary Louise, is the wife of Professor Elihu Thomson, of Swampscott, Mass., and another daughter, Caroline, is the wife of Mr. Henry B. Boardman, of New Britain, Ct.

MR. F. W. SABOLD, a well-known telephone and telegraph man, died at Albany, N. Y., April 16, aged forty-seven years. Mr. Sabold was considered one of the best telephone and telegraph men of his time, and when the American-Union Telegraph Company was organized he was made manager of the Indianapolis, Ind., office. In 1882 the American-Union Telegraph Company was taken up by the Western Union Telegraph Company, and Mr. Sabold was made manager of the Albany office. In 1890 he became manager of the Westchester Telephone Company, and after it was taken up by the New York Telephone Company he became superintendent of the Westchester division. Since 1902 he had been contract agent for the Hudson River Telephone Company.

ELECTRIC LIGHTING.

HEMPSTEAD, N. Y.—The town board of this town has voted to establish an electric lighting district at Merrick.

QUINCY, ILL.—The Quincy Gas and Electric Company has closed a contract for making $25,000 worth of improvements at its power-house.

WASHINGTON, D. C.—A bill has been passed appropriating $3,000 for an electric light plant for the Statue of Liberty, in New York harbor.

ALEXANDRIA, VA.—The city council has passed an ordinance providing that an electric light franchise be advertised for sale to the highest bidder.

ELY, MINN.—The new electric light and water plant has been completed and was recently accepted by the council. The cost was about $100,000.

LORAIN, OHIO—The Lorain Gas and Electric Company will install a new electric light plant, utilizing its present gas plant, now lying idle, as a power plant.

DOVER, DEL.—The council will borrow $10,000 for the purpose of making improvements to the municipal electric lighting plant, and it is hoped to have the plant in first-class condition by July 1.

PITTSBURG, PA.—At a meeting of the McKees Rocks council an eight-year contract was entered into with the Southern Light, Heat and Power Company for eighty-two arc lights at $70 each per year.

PHILADELPHIA, PA.—The People's Light, Heat and Power Company, of Shenandoah, and the People's Light, Heat and Power Company, of Mahanoy Township, will be merged, and a plant built to furnish light, heat and power to Shenandoah, Mahanoy and surrounding towns.

OCALA, FLA.—Colonel W. N. Camp, of Ocala, has made a proposition to the council for the purchase of the electric light and all appurtenances thereto, the price to be fixed by three appraisers. Colonel Camp has a project on hand by which he expects to utilize the waters of the Withlacoochee river, and agrees to furnish the city with at least a thousand horse-power.

NEW HAVEN, CT.—The power station in West Haven of the Fair Haven & Westville road is being converted into an illuminating plant, and will furnish all the power used at the Savin Rock resort next summer. For the extensive plans made for the new park at the Rock, about 10,000 incandescent lamps will be required, and to meet the demand for increased power, the company is making extensive alterations to the power-house at West Haven.

ALBANY, GA.—The city council has entered into a contract with the Albany Power Company, whereby the former will purchase from the latter sufficient power to operate the city waterworks and lighting plants. The Albany Power Company is the concern which recently acquired the Big Shoals water power, two miles north of the city, and it will at once proceed to develop it. Power will be furnished to the city and to other local manufacturing enterprises.

NEW RICHMOND, WIS.—The Western Gas and Investment Company, which owns the Apple River Power Company, and also holds the gas and electric lighting franchises in Stillwater, is about to begin improving the company's water-power properties along Apple river. The capacity of the plant in operation at Somerset, eight miles west of this city, which now supplies this city with electric light and power, is to be doubled, and another new dam and power transmission plant are to be installed a mile above Somerset. This will generate 700 horse-power, which will be transmitted direct to Stillwater.

HAGERSTOWN, MD.—Capitalists interested in the scheme to generate electricity at dam No. 5, along the Potomac river, are planning to make the enterprise far-reaching, and expect to be in position within the next year to furnish electric current to all cities and towns within a radius of twenty-five or thirty miles. It is said to be the purpose of the projectors to run lines to Hagerstown, Hancock and Williamsport, in Maryland, and Martinsburg, Shepherdstown, Berkeley Springs and other places in West Virginia. Several carloads of machinery have already arrived and the machinery is now being installed.

BALLARD, WASH.—At the regular meeting of the city council a franchise to operate an electric light and power plant in this city for fifty years was granted to H. A. Starkey. By the terms of the franchise, Mr. Starkey agrees to put up a bond of $5,000, to pay $2,500 to the city immediately, and, after five years, $300 annually during the remainder of the life of the franchise, in addition to a percentage of the gross receipts of the plant. He also agrees to have 2,500 sixteen-candle-power lights ready within four months, and 10,000 lights inside of six months, and to build a plant to cost $60,000, the same to be finished within six months from the acceptance of the franchise.

JUNCTION CITY, KAN.—The quarters, barracks and streets of Fort Riley are to be lighted by electric lamps. The Junction City Electric Railway Company will furnish the current for this purpose, and is now putting in a plant to do this work in addition to lighting Junction City and operating its railway line between this city and Fort Riley. The quarters and barracks at the post will have about five thousand incandescent lights and the post streets will have forty-three arc lights. By the terms of the company's contract with the government, the company will conduct the electrical current to a certain point on the military reservation, and the government will take charge of it at that point.

PERSONAL MENTION.

MR. J. F. LAWLESS, who was manager of the San Francisco Gas and Electric Company, San Francisco, Cal., has resigned.

MR. HENRY RUSTIN, chief electrical and mechanical engineer of the St. Louis Exposition, has resigned his position owing to his continued poor health.

MR. WILLIAM S. BROWN, sales agent for electrical supplies, announces that on April 30 he will remove his offices to larger quarters in the Bancroft Building, 3 West Twenty-ninth street, New York city.

MR. J. P. MOORE, of Columbus, Ga., who until recently was connected with the General Electric Company, Schenectady, N. Y., has accepted a position as electrical engineer for a mining company at Durango, Mexico.

MR. W. H. FITZHUGH, who is superintendent of the municipal electric lighting plant at Bay City, Mich., has been appointed electrical inspector under the ordinance governing electrical construction, which was recently adopted in that city.

MR. ALVA J. CARTER, of Georgie, Iowa, is at present representing the Monarch Telephone Company, of Chicago, Ill., with headquarters at Des Moines. Mr. Carter was formerly manager of the Ida County Telephone Company.

MR. C. T. MURDOCK has been appointed superintendent of the Terre Haute Electric Company's railway and lighting plant at Brazil, Ind. Mr. Murdock was formerly electrician for the street railway company at Terre Haute.

MR. ARTHUR WEST, assistant chief engineer of the Allis-Chalmers Company, has resigned and will go to the Mediterranean for a trip for recreation and rest. Mr. West's close application to business for several years has undermined his health and it becomes imperative for him to recuperate.

MR. JOHN KELLY, whose headquarters are at 2030 Madison avenue, New York city, N. Y., announces that he is prepared to make estimates on conduit installations of any size throughout the United States. Mr. Kelly has had considerable experience along this line, and has engineered the construction of many large systems.

MR. WALTER GREACEN, JR., has been placed at the head of both the gas and electric light departments of the Public Service Corporation of New Jersey. Mr. Greacen has been in charge of the electric light department for some time, coming to Hoboken, where the office is located, when Colonel S. D. Dickinson was made agent

of the electric light company. At this time he was cashier. When Colonel Dickinson was appointed secretary of state by Governor Murphy, Mr. Greacen was promoted to the position of agent, retaining this position up to this time.

MR. CHARLES F. FOSTER, M. Am. Soc. M. E., who is vice-president of the National Supply Company, Chicago, Ill., has been appointed chief operating engineer of the electrical plant at the St. Louis Exposition. It is reported that Mr. Foster will enter upon his new duties at once.

MR. R. G. ARNOLD, secretary and treasurer of the Arnold Electric Power Station Company, Chicago, Ill., was recently married to Miss Hazel McLane, daughter of Mr. G. A. McLane, of New York city. Mr. Arnold has for several years been connected with the Arnold Electric Power Station Company of which his brother, Mr. Bion J. Arnold, is president.

MR. W. H. BROWNE, general manager of the Stanley Instrument Company, Great Barrington, Mass., returned last week from an extended trip throughout the West and along the Pacific coast, and found the electrical interests of those sections very active and the demand for the Stanley products at Great Barrington increasing in volume.

MR. F. D. LAWRENCE, of the well-known electrical supply house of the Lawrence-Hall Electric Company, Cincinnati, Ohio, was a New York visitor last week. While there was a slight falling off in the electrical trade early in the year, Mr. Lawrence now reports a noticeable improvement, and states that the demand for Okonite products, for which his house is general agent, is constantly increasing.

MANAGING DIRECTOR TAYLOR, of the New Zealand Electrical Construction Company, which concern has secured $2,500,000 in contracts for the construction of the Christchurch municipal electric traction system, is said to be on his way to the United States, in connection with the placing of contracts for material, machinery, etc. Mr. F. Hubert Chamberlain, a former General Electric man, will have charge of the construction. Prior to his present position, he acted as construction engineer of the Sydney, City & Suburban Tramways, which are built largely of American material and operated by the New South Wales Government.

MR. ERVIN DRYER has resigned his position with the Westinghouse Electric and Manufacturing Company, and has accepted an appointment with the Allis-Chalmers Company. Mr. Dryer's connection with the Westinghouse company extended over a period of sixteen years. He is reputed to be one of the most competent salesmen in the electrical and mechanical field, and his wide acquaintance throughout the western part of the United States will be of great value to the Allis-Chalmers Company in the extensive developments which it has undertaken. Mr. Dryer's headquarters are at the offices of the Allis-Chalmers Company in the New York Life Building, Chicago, and he has already entered upon his new duties. He will give his attention to the company's engine work, as well as to the sale of Bullock electrical apparatus, which the Allis-Chalmers Company now controls through its acquisition of the Bullock Electric Manufacturing Company, Cincinnati, Ohio.

MR. GEORGE C. LLOYD has been appointed secretary of the British Institution of Electrical Engineers, in the place of the late W. G. McMillan. Mr. Lloyd was born in Lincolnshire in 1862. He was educated partly in Germany, and on returning to England at the age of seventeen he entered the works of Robert Stephenson & Company, locomotive and marine engine builders, Newcastle-upon-Tyne, as an apprentice. In 1884 he joined the firm of Messrs. Lamport & Holt, of Liverpool, in the capacity of marine engineer, and subsequently entered the service of the Spanish Royal Mail Steamship Company. During his association with this company, he made a number of trips to the Philippine Islands, and has also been in India, Brazil, the Argentine Republic and the West Indies, spending some months in Cuba. He returned to England in 1891, and for the next nine years was engaged in engineering work in Glasgow and London. Since 1900 Mr. Lloyd has acted as chief assistant to the secretary of the Iron and Steel Institute. It is understood that Mr. Lloyd is also an excellent linguist. He will begin his new duties on May 12. As assistant secretary, Mr. Percy F. Rowell, chief assistant to the late Mr. McMillan, has been appointed.

ELECTRICAL SECURITIES.

In the face of a more aggressive bear pressure than has been evident for a month, the market maintained a tone of stability that lends the hope that there is still possible a considerably favorable reaction. While current railroad earnings and bank clearances continue to reflect a lessened industrial activity, as compared with a year ago the situation is not such as to cause alarm, although the earnings for the first two weeks of April are disappointing, after the improving tendency which marked the last two weeks of the previous month.

ELECTRICAL SECURITIES FOR THE WEEK ENDING APRIL 23.

New York:	*Closing.*
Brooklyn Rapid Transit	47½
Consolidated Gas	207⅝
General Electric	164½
Kings County Electric	183
Manhattan Elevated	142½
Metropolitan Street Railway	114⅛
New York & New Jersey Telephone	144½
Westinghouse Manufacturing Company	175

Boston:	*Closing.*
American Telephone and Telegraph	126½
Edison Electric Illuminating	239
Massachusetts Electric	73½
New England Telephone	124
Western Telephone and Telegraph preferred	79

The American Telephone statement of output of instruments for March shows the largest month's output on record in both gross and net. The gross output amounted to 126,522, and the net output to 91,479. The net output since the close of the fiscal year December 31, 1903, was 192,578, making the total instruments outstanding March 31, 1904, 3,972,095. The indicated gain in the number of subscribers is about 75,000, making the total number of subscribers March 31 in excess of 1,600,000. The indicated gain in the gross earning capacity of the Bell system, at $50 per subscriber, is $3,750,000 per annum; and the indicated gain in net earning capacity is over $1,000,000 per annum. With the number of subscribers now at 1,600,000, the annual gross earnings of the Bell Telephone system will amount to $80,000,000, of which about $23,000,000 will be net earnings.

Philadelphia:	*Closing.*
Electric Company of America	8
Electric Storage Battery common	58
Electric Storage Battery preferred	58
Philadelphia Electric	5⅛
Union Traction	49⅜
United Gas Improvement	82

Philadelphia Electric directors have reelected old officers. The general balance-sheet of the company as of December 31, 1903, shows assets of $41,080,615, and liabilities of $40,280,481, leaving a surplus of $800,134, as compared with $563,568 for the previous year.

The annual meeting of United Gas Improvement stockholders will be held May 2.

Chicago:	*Closing.*
Chicago Telephone	115
Chicago Edison Light	148
Metropolitan, Elevated preferred	46
National Carbon common	28
National Carbon preferred	102
Union Traction common	5½
Union Traction preferred	30

The Chicago Edison Company's directors have declared the regular quarterly dividend of 2 per cent, payable May 2. The annual report of the company for the year ended March 31, 1904, is as follows: gross, $3,837,659; expenses, $2,515,050, leaving net earnings of $1,322,619; charges and dividends, $1,027,614, leaving a surplus for the year of $295,005, as compared with a surplus of $319,593 for the preceding year. The general balance-sheet as of March 31 shows total assets of $18,186,650, and total liabilities of $17,389,562, the surplus amounting to $797,088.

The National Carbon regular quarterly dividend of 1¼ per cent on the preferred stock is payable May 14. Books close May 1 and reopen May 16.

The Chicago Union Traction Company reports gross earnings of $7,236,628, for 301 days ending February 17, 1904, or $23,629 per day, against $21,373 per day for the year ending June 30, 1902. The gain is about 10 per cent for two years.

NEW INCORPORATIONS.

NARKA, KAN.—Ida Mutual Telephone Company. $1,000.

GODDARD, KAN.—Goddard Telephone Company. $2,000.

LINCOLN, NEB.—The Verdigre Telephone Company. $1,000.

LANSING, MICH.—Memphis Telephone Exchange. $10,000.

CONWAY, KAN.—Conway Rural Telephone Company. $10,000.

STAR CENTER, KAN.—Star Center Telephone Company. $2,500.

LINCOLN, NEB.—The Kenesaw Telephone Company. $10,000.

LAKE CRYSTAL, MINN.—Blue Earth County Telephone Company. $25,000.

MADISON, WIS.—The Muscoda Mutual Telephone Company. Increased to $11,000.

BINGHAMTON, N. Y.—Telephone Company. $500. Incorporators: C. S. Gage, George W. Vosburg, E. M. Jaycox.

CAMDEN, IND.—Cooperative Telephone Company. $4,000. Directors: J. S. Plank, F. G. Armick and O. W. Wyatt.

CASCADE, MICH.—The Cascade Electric Company. $15,000. Directors: E. A. Howe, C. C. Folmer and Charles E. Mercer.

RICHMOND, VA.—Rockingham Mutual Telephone Company; increased to $25,000. Broadford Telephone Company, $5,000.

ALBION, N. Y.—Home Telephone Company. $50,000. Directors: C. M. Beattie, G. Babcock, Rochester; G. L. Merrill, Albion.

LITTLE ROCK, ARK.—The Jacksonville Telephone Company. $1,000. Incorporators: S. W. Murtishaw, W. C. Graham, E. C. Stone.

GALESBURG, ILL.—Oak Grove Telephone Company. $500. Incorporators: Thomas R. Castle, Ellery Stegall and Herbert R. Griffith.

DUNDEE, N. Y.—Dundee & Crystal Springs Telephone Company. $5,000. Incorporators: Delmar J. Knapp, L. Pitcher, Edward J. Bailey.

INDEPENDENCE, KAN.—Kansas Electric Railroad Company. $100,000. To operate an electric railway in Montgomery and Labette counties.

NEWARK, N. Y.—Newark Telephone Exchange. $25,000. Incorporators: Ernest A. Smith, John E. Pulver, Edward P. Thatcher, Newark, N. Y.

EAST LYNN, ILL.—Fountain Creek Telephone Company. $34,000. Incorporators: William A. Yeasel, George H. Wieland and Harry H. Tucker.

SAN FRANCISCO, CAL.—Reno Light and Power Company. $1,000,000. Directors: P. L. Flanigan, W. H. Patterson, J. A. Fontaine, C. L. Gibb and F. P. Deering.

NASHVILLE, TENN.—The Dayton Electric Light and Power Company. $10,000. Incorporators: T. E. Stone, J. T. Dean, N. D. Read, W. C. Bailey and J. B. Swafford.

WASHINGTON, D. C.—Nebraska Central Electric Railway Company. $1,500,000. Incorporators: B. S. Donaldson, E. W. McCormick, James F. Shepperson, S. A. Terry.

CARPENTER, OKLA.—The Elk City Northern Telephone Company. $5,000. Incorporators: Joseph Moad and J. A. Hart, of Carpenter; S. J. Tippins and D. L. Cliff, of Colter.

JEFFERSON CITY, MO.—Laddoniz, Rush Hill & Mexico Union Telephone Company. $1,000. Incorporators: J. N. Rosser, E. A. Featz, C. L. Stewart, J. C. Maxwell and T. J. Roberts.

BOSTON, MASS.—Silver City Water and Electric Company. $900,000. Directors: Marcellus Coggan, Malden, Mass.; Horace D. Gove, Arthur T. Dyer, Robert B. Edes, Charles W. Gledden, Hugh Montague and Francis M. Slattery.

INDIANAPOLIS, IND.—The Evansville & Henderson Traction Company. $10,000. To construct an electric line from Evansville, Ind., to Henderson, Ky. Directors: H. E. Randall, C. C. Tennis, C. H. Baltin, E. S. Reitman and J. W. Pritchard.

INDIANAPOLIS, IND.—Columbus, Greensburg & Richmond Traction Company; $1,000,000; directors, August M. Kuhn, Amos Hollowell, Milton Reeves, Walter McConaha, William Meyer, Charles Wilson and Harris Holland. Cincinnati, Bluffton & Chicago Railway; $100,000; incorporators, Hugh Dougherty and others.

TELEPHONE AND TELEGRAPH.

SLOAN, IOWA—The People's Rural Telephone Company has been incorporated with a capital of $2,500.

SANGER, TEX.—The Independent Telephone Company is putting in a line from Gainesville to Fort Worth.

STORY CITY, IOWA—The Gilbert & Story City Telephone Company has been formed to build a rural line.

MULLICA HILL, N. J.—The township committee has granted permission to the People's Rural Telephone Company to install its poles and wires in this township.

NEW CASTLE, IND.—The local independent telephone company has completed a line to Kennard, which is a link in a direct line to Indianapolis. At present the latter city has to be reached through Knightstown and Greenfield.

SARATOGA SPRINGS, N. Y.—The directors of the New Union Telephone Company have decided to sell their system to the Commercial Union Telephone Company, which has been organized to buy the Troy, Saratoga and Glens Falls systems.

COLUMBUS, OHIO—The Central Ohio Telephone Company, of Centerburg, has been incorporated by Charles L. Bishop and others, and will operate a telephone system in Knox, Morrow, Licking and Delaware counties. The capital stock is $10,000.

LINCOLN, NEB.—The Wray Telephone Company of Colorado has filed articles of incorporation with the secretary of state. The company will extend lines in Nebraska to enable the Nebraska Telephone Company to connect with the Colorado Bell Telephone Company.

LEAD, S. D.—The Home Telephone Company, which recently took over the rights of the Harrison Telephone Company, is now at work improving the system. The lines connecting Lead with adjoining towns are being rebuilt, and new plants are to be installed in Lead and Deadwood.

ROWE, MASS.—At the annual meeting of the Rowe Telephone Association the following directors were elected: A. P. Goldthwait, P. P. Chilcott, Joseph Sibley, Ellis Potter, R. R. Fisk, B. T. Henry, G. F. Maxam. A. P. Goldthwait was elected president and P. P. Chilcott vice-president.

WHATCOM, WASH.—The Canadian Bell Telephone Company is making arrangements to give the city of Bellingham telephonic communication with adjacent islands and the city of Victoria. The entire line will be built of the best grade of copper wire and will cost between $75,000 and $100,000.

RUSHVILLE, IND.—The annual meeting of the stockholders of the Rushville Cooperative Telephone Company was held recently, at which time H. E. Barrett, W. D. Root, L. McFarlan and T. M. Green were elected directors. The annual report showed the receipts to be $15,404.91, and the disbursements $14,664.78.

UNIONTOWN, PA.—It is stated that the lines of the Pittsburg & Allegheny Telephone Company will shortly be connected up from Pittsburg to Baltimore and Philadelphia. This will be accomplished by direct connection with Johnstown, Somerset, Cumberland, Hagerstown, and thus straight through to Baltimore. The Johnstown connection is over the new Johnstown & Pittsburg Telephone Company's lines.

FALL RIVER, MASS.—At the annual meeting of the Fall River Automatic Telephone Company the following directors were elected: E. B. Jennings, William J. Dunn, R. J. Thompson, R. F. Haffenreffer, Jr., P. A. Mathewson, M. Sweeney, Quinlan Leary, V. A. Sears, Martin Feeney, R. P. Borden and B. D. Davol. The balance-sheet of the company shows total assets of $222,936.02, and liabilities of $211,203.82, leaving a surplus of $11,732.20.

WILKESBARRE, PA.—Charles West, W. G. Harding and associates have purchased the Citizens' Telephone Company, of Honesdale, and have reorganized it under the name of the Honesdale Telephone Company, with a capital of $40,000. The new management has already received contracts for 100 additional telephones, which will be installed immediately, and will also build a long-distance line to Carbondale, giving its patrons connection with the territory covered by the Consolidated Telephone Companies of Pennsylvania, and through its allied companies with towns and cities in New Jersey, New York and Pennsylvania.

ELECTRIC RAILWAYS.

HARTFORD, CT.—The Somers & Enfield Electric Railway Company has been absorbed by the Hartford & Springfield Railway Company, the price paid being $165,333.

RAPID CITY, S. D.—It is announced by C. D. Crouch, of Akron, Ohio, that the Black Hills & Wyoming Railroad, connecting Rapid City and Mystic, will be built this year.

MONONGAHELA, PA.—A new trolley line is to be constructed from Monongahela to Ellsworth, by way of Bentleyville, by a company known as the Monongahela, Bentleyville & Ellsworth Railway Company. The road will be fifteen miles long.

MINNEAPOLIS, MINN.—Another electric line from Minneapolis to Stillwater has been projected by the Minnesota Power and Trolley Company. As already laid out, the line will run from Minneapolis to the north shore of White Bear lake and on to Stillwater.

BEDFORD, IND.—The Bedford Street Railroad Company, which received a franchise two months ago under certain conditions, has accepted the same and filed a bond of $5,000 to begin work on the road by September 1 and to have the same completed within eighteen months from that date.

PHILADELPHIA, PA.—Lower Merion township commissioners adopted an ordinance granting right of way to the Bala Street Railway Company and the Lower Merion Street Railway Company. These two trolley roads will connect with Ardmore, Merion Square, West Conshohocken, Bala, Cynwyd and Philadelphia.

ST. LOUIS, MO.—The Manila & Southeastern Railroad has filed an application for a charter. The directors are D. A. Smith, C. R. Davis, B. W. Cowan, Sam Lavine and R. L. Williford. The capital stock is $150,000. It is proposed to build a line from Manila, Mississippi County, Ark., to Culberhouse, Craighead County, a distance of twenty-four miles.

PORT JEFFERSON, N. Y.—The Central Long Island Electric Light and Railroad Company has secured an extension and amendment of franchise of the former Patchogue & Port Jefferson Traction Company. The railroad has been duly incorporated and organized under the railroad law of the state of New York, and has acquired by purchase all the capital, stock, rights and franchise of the aforesaid traction company.

TRIPOLI, IOWA—A company is being organized here for the purpose of building an independent line from Anamosa, through Independence to Tripoli and up the river to Nashua, thence to Mason City. There is an old roadbed part of the way between this place and Independence which can be used for the new line. A large amount of capital is back of the project, and the promoters expect to push construction.

OWOSSO, MICH.—The Owosso & Corunna Electric Company, which operates the electric line from this city to Corunna and furnishes light for the city of Owosso, has been sold to a Pennsylvania syndicate which controls several lines around Allentown, Pa., and also has the control of the public lighting in Flint. The company has secured an extension of the franchise in Owosso and Corunna and will extend the road to Durand.

YOUNGSTOWN, OHIO—Announcement is made by the Youngstown & Sharon Railway Company that it will build a power-house along its line at Lisbon. Contracts for the plant are now being let, and it is the intention to begin work of construction just as soon as the weather opens in the spring. According to plans the plant will contain two 1,000-horse-power and one 500-horse-power engines. These will supply the entire motive power for the line.

PARIS, ILL.—The American Central Traction Company, at Taylorville, has received from an eastern company an estimate of the cost of the proposed interurban line from Taylorville to Assumption and Shelbyville. This estimate, including rolling stock, power-house, wires, poles, etc., places the cost at $20,000 per mile. The distance to Assumption is sixteen miles, so that the approximate cost of building the line will be $320,000. The line to Mt. Auburn has been abandoned, and only the Assumption-Shelbyville line will be built at present.

BLUEFIELD, W. VA.—The Bluefield & Graham Electrical Railway Company is making rapid progress in the construction of its line between this city and Graham. Work has been commenced on the Graham end of the line, and a large number of the ties have been put down. The distance of this line will only be three miles at the present, but a franchise granted to the company gives the company the privilege of extending its line throughout the coal field, and to Princeton, the county seat of this county. John Walters, of Graham, Va., is president of the company.

INDIANAPOLIS, IND.—The Union City, Winchester & Muncie Traction Company has filed articles of incorporation with the secretary of state, with a capital of $10,000. It is provided in the articles that the capitalization may be raised to $2,000,000 at any time. The company proposes to build an interurban line running from Union City to Muncie, connecting at Union City with the proposed Greenville & Union City Traction Company. The incorporators are Dr. J. E. Lowes, John E. Feight, Walter B. Gebhart, Ralph De Weese and Charles M. Anderson, of Greenville, Ohio, and Theodore Shockney, of Union City.

KITTANNING, PA.—The Kittanning & Ford City street railway is to be extended sixteen miles from the latter place to Leechburg, where it will connect with the proposed line to Arnold on the Valley road. From Arnold a line is already in operation through New Kensington and across the river at that place, where in turn connection is made with the Tarentum trolley road to Creighton. A road is now in operation from Pittsburg to Verona and the road is constructed to Hulton. Six miles of new road down the west side of the Allegheny river and a bridge over the stream at Hulton would give a through trolley line from Kittanning to Pittsburg.

WINDSOR LOCKS, CT.—The contract for the building of a trolley line from Windsor, through the town of Windsor Locks and to the centre of the town of Suffield, thus completing a through street railway between Hartford and Springfield on the west side of the Connecticut river, has been awarded to the National Construction Company. The Windsor Locks & Rainbow Street Railway Company, whose franchise was recently bought by the firm of Tucker, Anthony & Company, of Boston, and the Suffield Street Railway Company are jointly interested in the road. The Suffield company will build that part of the line which lies within the town of Suffield, and the Windsor company will construct the balance.

ROCHESTER, N. Y.—A preliminary organization of a new trolley company to be known as the Rochester, Scottsville & Caledonia Railway Company was effected at a meeting held recently. Those present included Henry C. Brewster, John F. Alden, Michael Doyle, Selden S. Brown, Eugene B. Brown, Charles H. Palmer, Willard E. Moore, Dewitt C. Becker, Thomas Brown, Isaac W. Salyerds, F. Marks, Le Grand Brown, Walter A. Parse, Carroll E. Bowen, Andrew H. Bown and Senator Merton E. Lewis. The company plans to construct an electric railway from Rochester to Scottsville, Mumford and Caledonia, and eventually it is thought the road will be extended through Pavilion and Perry to Silver Lake.

TERRE HAUTE, IND.—It is announced by the officers of the Indianapolis, Danville & Rockville Traction Company that its line will be completed as far as Danville, Ind., by July 1. All of the heavy grading has been completed. The bridges to be used, the most important of which will span White Lick, near Avon, are already constructed and can be swung into place in a comparatively short time, and work on the power-house, at Danville, will begin as soon as the weather will permit. The car barns will be built in connection with the power-house. The line will be about twenty miles long and will be practically a straight line west from the city. The extension to Rockville, Ind., will begin after the Danville division is completed.

FINDLAY, OHIO—One of the promoters of the Lake Erie & Southern Electric Railway, from Toledo to Columbus, *via* Fostoria and Marion, states that the road is an assured fact. The company has been organized and capitalized at a million and a half dollars and all of the stock has been subscribed. The line will be built from Toledo to Marion this year, and will connect at Marion with the line already built and in operation into Columbus. It will pass through Fostoria, Upper Sandusky and intermediate points. The total length will be seventy-eight miles, and the average population for the whole line to the mile is 3,300. The company will do the work of construction itself, and will let the contract for building the road June 15.

INDUSTRIAL ITEMS.

THE AMERICAN AUTOMATIC SWITCH COMPANY announces that its offices have been moved to 52 Broadway, New York city, N. Y.

THE PACIFIC ELECTRIC COMPANY, La Crosse, Wis., electrical dealer and manufacturer of adjustable shade lamps, has made an assignment.

THE CROCKER-WHEELER COMPANY, Ampere, N. J., is distributing its bulletin No. 44, which is descriptive and illustrative of the Conneaut & Erie Interurban system. Bulletin will be sent on request.

THE MINNEAPOLIS STEEL AND MACHINERY COMPANY, Minneapolis, Minn., describes the "Twin City Corliss Engine" which it manufactures in a fine catalogue which it has just issued. A number of half-tone plates show the works of the company and illuminate the discussion concerning the construction of the engine.

THE NATIONAL ELECTRIC COMPANY, Milwaukee, Wis., has issued a handsome catalogue descriptive of "National" electric machinery. This is designated as catalogue No. 61. In addition to the reading matter, there are a number of fine illustrations of direct-current generators and motors for lighting, power and railway service.

THE LUNKENHEIMER COMPANY, Cincinnati, Ohio, manufacturer of steam engineering specialties, has distributed to its sales offices and to all jobbers handling its product a substantial and handsome tin hanger. This hanger is beautifully lithographed, and represents a standard two-way globe valve held in the hand for inspection.

THE AMERICAN PUSH-BUTTON TELEPHONE COMPANY, whose name on and after May 7, 1904, will be Anders Push-Button Telephone Company, is sending out a little catalogue illustrating, describing and listing its push-button telephones, together with a leaflet containing specifications of "Anders" push-button telephone and parts and two leaflets containing diagrams and instructions for connecting up the telephone. Both of these leaflets and the catalogue will be sent on request.

THE H. T. PAISTE COMPANY, Philadelphia, Pa., manufacturer of the celebrated "P-K" electrical supplies, is distributing supplement No. 11 to catalogue No. 10. This supplement illustrates and describes those new specialties which the company has added since issuing its latest general catalogue. The company would be pleased to send samples for examination. When requests are made for samples the catalogue number of the article desired should be given. Information regarding prices and discounts will be gladly furnished.

THE GARVIN MACHINE COMPANY, Spring and Varick streets, New York city, manufacturer of metal working machine tools, will be pleased to send its complete illustrated catalogue to parties interested in this material. This catalogue illustrates and describes in detail the apparatus manufactured by the Garvin company. In addition to the descriptive matter, there is a quantity of valuable information for the machinist and metal worker. A carefully prepared index facilitates the finding of any particular product.

THE ELECTRICAL TESTING LABORATORIES is the legal title of the corporation heretofore known as the Lamp Testing Bureau. This new corporation is the successor in every respect to the Lamp Testing Bureau, without change of officers or functions. The office and laboratories have been removed from 14 Jay street to Eightieth street and East End avenue, New York. The officers are John W. Lieb, Jr., president; Charles L. Edgar, vice-president; E. A. Leslie, treasurer; Wilson S. Howell, secretary and manager; Clayton H. Sharp, Ph. D., test officer, and A. E. Kennelly, Sc. D., consulting engineer.

THE GOULD STORAGE BATTERY COMPANY advises that on and after May 1 it will occupy the entire eighth floor of the New Century Building, 1 West Thirty-fourth street, New York city. The company is making every effort to supply a continually increasing demand for its complete storage battery plants and counter-electromotive-force booster systems. The company's sales offices are in New York, Boston, Chicago and San Francisco, with the works at Depew, N. Y. A number of accurately prepared bulletins describe typical installations of these systems. These bulletins the company will be pleased to send to any one interested upon request.

THE GENERAL ELECTRIC COMPANY, Schenectady, N. Y., has issued its price list No. 5121, which is to supersede price list No. 5063. The company is also distributing its bulletins Nos. 4369, 4370, 4371 and 4372, together with an interesting booklet containing a reprint of a paper read before the New England Association of Electric Lighting Engineers, March 18, 1903, on "Notes on Series Street Incandescent Lighting." In bulletin No. 4369 direct-current motor controllers for power and mining machinery are comprehensively described and illustrated. Bulletin No. 4370 treats on three-phase air-blast transformers. Bulletin No. 4371 describes and illustrates electrostatic ground detectors. Bulletin No. 4372 treats on blueprinting with enclosed arc lamps. All of the publications mentioned will be sent on request.

THE KELLOGG SWITCHBOARD AND SUPPLY COMPANY, Chicago, Ill., has issued a new catalogue entitled "Magneto Switchboards." For some years the Kellogg company has been publishing a series of catalogues which embodies the highest qualifications of the printers' art. This catalogue is a worthy successor of those which have gone before. As an instance of the careful manner in which this catalogue is prepared, where it will simplify the illustration the circuits and windings are indicated by more than one color, making the diagrams of particular value and interest. The frontispiece is an illustration in color of an operator working on a magneto switchboard. The Kellogg company will make a special exhibit in the Electricity Building during the Louisiana Purchase Exposition. Special arrangements have been made for the comfort of the company's guests at this time, and a cordial welcome is assured by the management to those who wish to make their headquarters at the company's exhibit.

THE BRISTOL COMPANY, Waterbury, Ct., is sending an exhibit to the World's Fair at St. Louis, which will be located in the Electricity Building. The booth is situated alongside of the main entrance in space No. 36. The company will show a complete line of Bristol recording instruments for pressure, temperature and electricity. The exhibit will consist of various styles and sizes in different finishes. The constructive and operative parts will be shown, and a large number of the instruments will be in actual operation, enabling visitors to observe the manner of working and the records which the instruments make. Especial attention will be directed to the extreme simplicity of the different types, and the delicacy and accuracy which it is possible to obtain, without sacrificing any of the necessary elements which are essential in a commercial form of recording instrument. There will also be shown a complete line of specimens of Bristol patented steel belt lacing, which comprises over 150 sizes for all kinds of belting, from the thinnest to the heaviest belts manufactured, such as are used for conveying belts.

J. G. WHITE & COMPANY, INCORPORATED, 43-49 Exchange place, New York city, has been retained to reconstruct the thirty-mile interurban railway of the Conneaut & Erie Traction Company. This work will include the installation of a storage battery and feeder system. J. G. White & Company, which has hitherto confined its attention to electrical engineering and contracting work, has now taken substantial contracts for harbor improvements and street paving in the Philippine Islands. One contract calls for the construction of a bulkhead and dock about 2,600 feet long, the bridging of the channel adjacent to the bulkhead, and the filling-in of the area immediately back of it. This work is at Cebu. Another contract is for the construction of 6,100 lineal feet of fascine bank protection, comprised of piles, mattresses and stone; the construction of 1,530 lineal feet of stone jetties; the dredging of 410,000 cubic yards of material in the river channel, and the disposing of the material back of the dykes at Iloilo. These contracts, which were awarded by the bureau of engineering, government of the Philippine Islands, will entail an expenditure of some $800,000. About $150,000 will be expended in the United States in the purchase of hydraulic and dredging equipment. The company has also been awarded the contract for street paving in the city of Manila, where it is now building an extensive electric traction and lighting system, which will be operated by an American syndicate, in which company Ex-President F. H. Buhl, of the Sharon Steel Company; Charles M. Swift, of Detroit, and others are largely interested.